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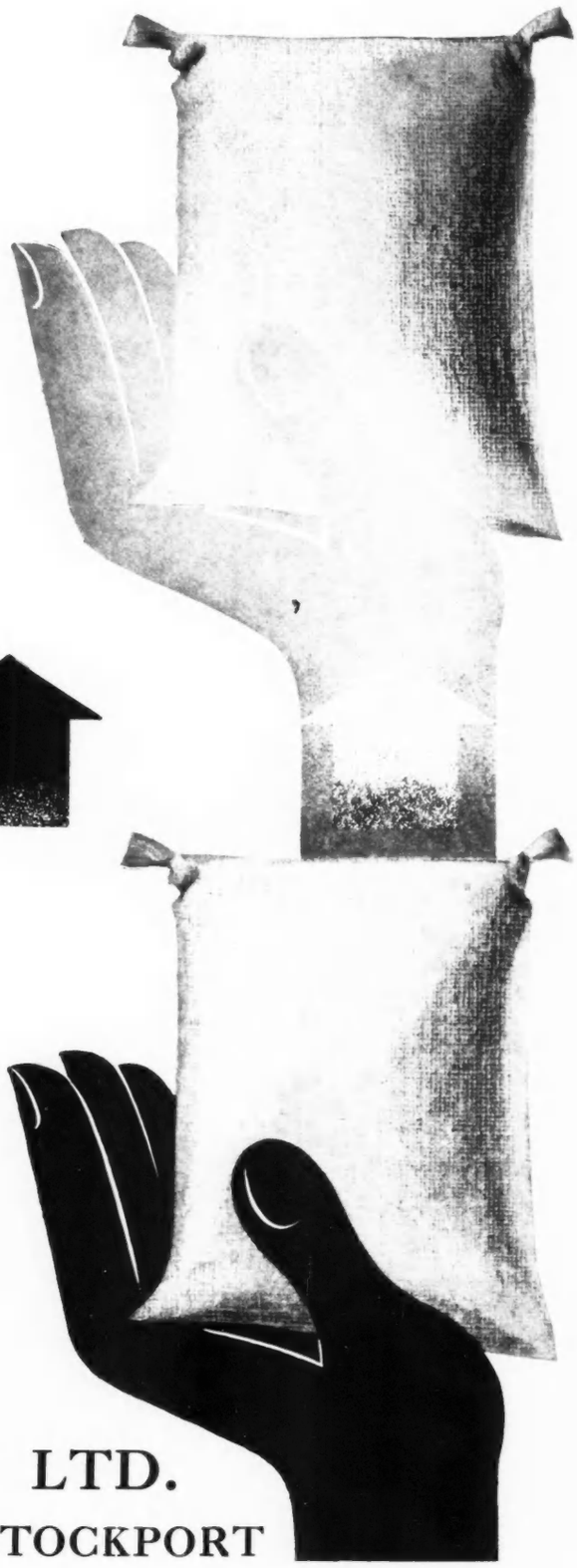

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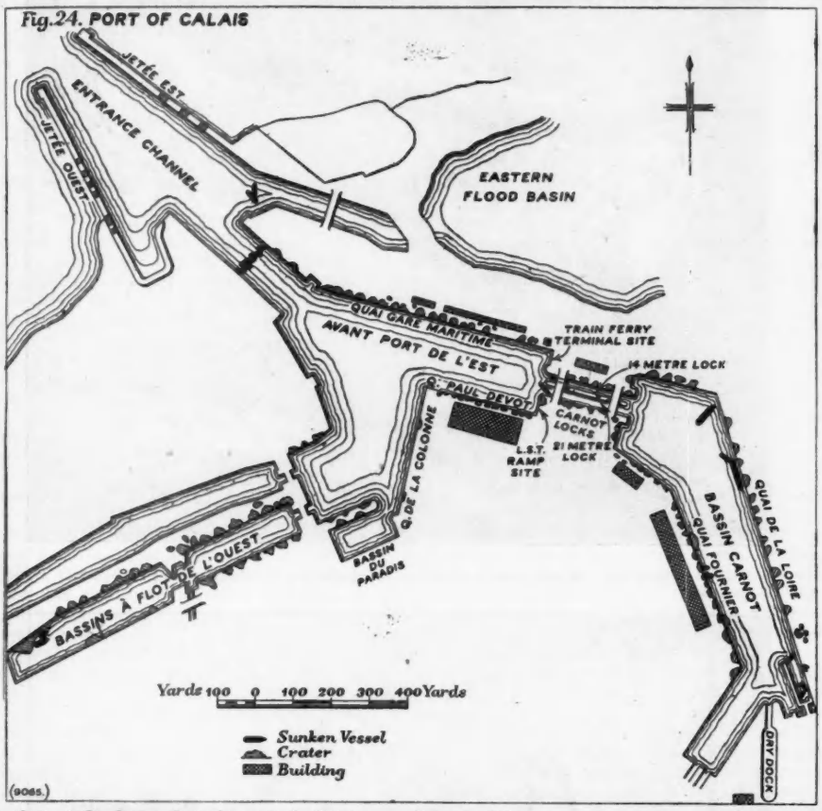
EMERGENCY REPAIRS AT CONTINENTAL PORTS.

(*Concluded from page* 434.)

CALAIS fell to the Canadian Army on October 1, 1944, and a reconnaissance of the port, of which a map is given in Fig. 24, on this page, was made immediately by Royal Engineer officers. Military operations at that time, however, were very fluid, and owing to uncertainty regarding the future development of the lines of communication, no definite plan for Calais was formulated until October 22, when it was decided to carry out a limited scheme of repairs. As shown in Fig. 25, on page 482, the damage in the area of the port due to Allied bombing and German demolitions, was considerable. The blocking of the entrance channel did not present such a problem to the Royal Navy as that at Boulogne, but the port facilities were completely wrecked. The buildings in the port area and that part of the town bounded by the Canal de Calais, the canal basins and the Bassin Carnot, had been almost wholly reduced to heaps of rubble. All the quays were cratered as a result of prepared demolitions, all dockside machinery and cranes were wrecked, and much of the wreckage had been blasted into the water. The Gare Maritime, the power station, and all the sheds had been demolished; and the locks, their gates and swing bridges were very badly damaged.

Fig. 24. PORT OF CALAIS



The construction of a train-ferry terminal and a ramp for two tank-landing ships (L.S.T.) was commenced immediately, to be followed, as soon as possible, by repairs to the quays in the tidal portion of the harbour—the Avant Port de l'Est. The original train-ferry terminal at the south-east corner of the Bassin Carnot, which had been constructed by the Royal Engineers during the war of 1914-18, was completely wrecked, so a new site at the east corner of the Avant Port de l'Est was chosen for the new terminal. The train-ferry vessel was to lie alongside the damaged Quai Gare Maritime, which was provided with fenders, and discharge on to the end quay which is situated close to the Carnot locks. This resulted in the connection being built over a steps recess in the face of the end wall, as shown in the illustration of the terminal, Fig. 27, on page 492, but no particular difficulties were encountered in the construction. Railway tracks were laid, and timber ramps were provided to mate with the vessel's hinged ramp and thus provide a smooth platform for unloading road vehicles. A crater in the Quai Gare Maritime, opposite the berth, was repaired, and two fenders were constructed from steel box piles fabricated from captured enemy stocks of steel sheet piles. Construction of the terminal was started on October 25, and completed on November 15, except for the fixing of a bearing pad, which arrived from England with the first ferry vessel on November 21.

The L.S.T. ramp was built at the eastern end of the Avant Port de l'Est, at the opposite corner to the train-ferry terminal, between the Carnot locks and the Quai Paul Devot. Suitable road and rail exits could be provided at this place, although several obstacles had first to be removed. The largest of these was an enemy gun emplacement of massive reinforced-concrete construction, which was demolished with a single charge of 8,000 lb. of explosive. The ramp was made of 8-in. thick reinforced-concrete, about 115 ft. in width and 125 ft. long, on a slope of 1 in 6, joined to a 50-ft. long approach by a curved stretch 30 ft. in length. The side slopes were pitched with pre-cast concrete units at an angle of 1½ in 1. Two sets of standard-gauge railway track were laid in the ramp, in line with the centre-lines of the two berthed vessels, and wheeled platform ramps, moved by winches, were fitted to the tracks for unloading rolling-stock. It was intended to construct the main portion of the first half of the ramp in dry conditions behind the existing quay wall, but, unfortunately, the wall burst, and the remaining work had to be carried out under tidal conditions. The first berth was completed on November 27, 1944, and the second on December 20.

Quay repair work at Calais was started on October 25, at the Quai Paul Devot, where the solid masonry wall had been cratered by prepared demolitions. Wreckage on the quay and in the water was cleared, and the craters repaired with brickwork and mass concrete for the wall, and a back-filling of rubble surfaced with sand and gravel. This work was completed by December 31, 1944. After divers had cut up and cleared the underwater wreckage as far as possible, the berths were dredged to a depth of 20 ft. below chart datum. Further dredging was carried out during March, 1945, to attain 22 ft. 6 in. depth of water. It was a difficult task because the spoil was fouled by rubble, twisted rails, crane steelwork, etc., and the lower tumbler of the dredger frequently became entangled with old steel-wire rope, which bound itself tightly and was very troublesome to remove. Meanwhile, on November 13, 1944, the restoration of the Quai Gare Maritime, including underwater clearance by divers and dredging, had been commenced. This quay was originally a solid gravity-type masonry wall, but in 1937 it had been faced with heavy-section steel sheet piling to enable an increased depth of water to be obtained without recourse to underpinning. The quay was cratered at about 120-ft. centres, and although the demolition charges had not produced such large craters as were found in masonry or concrete quays, the resultant damage was more difficult to repair. In some cases the steel piling was torn open, leaving protruding jagged edges, and in others the result was an irregular bulge in the face of the quay. It was impossible to restore the quay to its original line in the short time allowed, so it was decided to fill in the craters behind a temporary concrete retaining wall to enable the quay to be re-surfaced, cut away the protruding piles, and construct a line of vertical fenders, 6 ft. 6 in. from the original face, at which ships could berth clear of the bulges. The fenders consisted of 12-in. by 12-in. vertical timbers at about 3 ft. 6 in. centres, bracketed to the existing steel piles with rolled-steel joists. The first vessels to berth, however, soon broke the timbers, and the remaining sound ones were, therefore, faced with steel sheet piles bolted thereto, as shown in Fig. 28, on page 492. Fenders built after this were of an improved design; each timber was supported by a sheet pile at the back and provided with two steel rubbing rails at the front.

This improvement, however, was still inadequate, as the projecting rubbing strips of ships applied a point load on a single fender. A new arrangement of fender piling was therefore put in hand in May, 1945. Each fender consisted of three No. 3 Larssen box piles at about 2 ft. 6 in. centres, tied with 12 in. by 1½ in. timber waling and steel angles, and bracketed to the existing quay piles with timber struts. The piles were 70 ft. in length, driven to a penetration of about 15 ft., and bent inwards to an angle of 1 in 12 above a point 12 ft. from the top. The kink was formed after driving, by making a taper cut from the back, bending inwards towards the quay, and welding up the cut. The original fenders were removed subsequently, whenever they were broken. The first personnel ship had berthed at the Quai Gare Maritime on December 23, after which the quay was in constant use, up to 7,000 men embarking and an equal number disembarking in a day.

In October, 1944, it was decided to carry out temporary repairs to the Carnot locks, to provide berths in the Bassin Carnot for civil relief and rehabilitation purposes. There was a 14-m. lock on the north side and a 21-m. lock on the south side, both about 700 ft. in length, with a central island between the two. Each lock had four pairs of gates, and the whole system was spanned by two swing bridges, one at the east end and one at the west end. The demolitions were extensive: a wrecked vessel blocked each lock entrance, the swing bridges had been destroyed in the usual manner (the pivot portion was blown, leaving a cumbersome mass of steelwork), most of the 14-m. lock gates had been damaged, and all the 21-m. lock gates had been either partly damaged or completely wrecked. There were seven or eight craters in the walls of each lock, and the lock pits and gate sills were obstructed by rubble, large blocks of masonry, steelwork, and other debris from the demolitions. Fig. 29, on page 492, shows some cratering in a wall of the 14-m. lock, with German concrete air-raid shelters in the background to the right. Repairs were started on November 18, 1944. The removal of underwater debris was difficult, owing to strong tidal currents, and divers could only work for short periods at high- and

low-water slack; therefore, as much debris as possible was removed by grabs. One grab was operated by a 10-ton derrick on a Gambia pontoon, another by a crane which was moved on to the central island over a Bailey bridge erected for the purpose, and a grab dredger worked inside the lock pits. Fig. 26, on this page, shows the work in progress; a 40-ton floating sheerlegs, for handling a diving-bell, can be seen on the left of the illustration. At the 14-m. lock, the wrecked vessel was removed, the damaged swing-bridge was jacked up and pulled clear of the lock wall, and the craters were repaired with a concrete retaining-wall and rubble back-filling. The four sets of damaged gates could not be repaired effectively, so two good sets were made up from them and re-hung. This necessitated the construction of new anchor blocks and the installation of the top hinges for both pairs. Temporary operating gear, consisting of hand winches and steel-wire ropes, was provided. The 14-m. lock was thus restored to a serviceable condition by the end of March, 1945.

The gates at the 21-m. lock being severely damaged, it was decided to dispense with them, and to employ a caisson at the dock end of the lock. Two of the gate-leaves were sufficiently stable for them to be pulled back into their recesses, but the other six leaves were cut up and scrapped. The overhanging wrecked portion of the swing bridge was cut up, using explosives and oxy-acetylene cutters, and removed. The craters in the lock walls were repaired, the culverts checked, and dammed where necessary, and the blockship at the entrance and debris in the lock were removed. The caisson, which is shown in position in Fig. 30, on page 492, was known by the code name "Shark," and consisted of nine sections, each 7 ft. thick, 30 ft. high and 40 ft. wide. This sectional design had been evolved to provide caissons of different widths, thus avoiding elaborate masonry work on the site. Each section was fabricated in the United Kingdom, by welding steel plates together, and each incorporated a 24-in. diameter culvert with sluice valve, and inlet valves for admitting or discharging (by means of compressors mounted on the top of the caisson) water into or out of the section. The caisson was towed to the site in sections, each lying horizontally, and built up by ballasting them to the vertical position, in which they were bolted together to form a caisson 63 ft. wide. A detachment of Royal Engineers had been trained in the United Kingdom in the handling of a sectional caisson, but the task at Calais proved more difficult, owing to the size of the caisson (which was greater than the one used during training), the strong tide racing through the open locks, and the severe damage to the lock walls. The caisson was floated into position on March 2, 1945, and the 14-m. gates were closed for the first test. Some difficulties were encountered, but these had been overcome, and a civilian crew trained to operate the caisson, by the end of April. The caisson was sealed in position at the end of the lock by means of two timber flaps with hemp seals, one at each vertical corner edge on the impounded side, and a thrust block and seal resting on the former lock-gate sill, which was extended and modified for this purpose. Winches and bollards were fixed for manipulating the caisson, and timber fendering was fixed on the seaward face to protect the caisson, as shown in Fig. 30.

While the locks were being restored, the craters in the two main quays in the Bassin Carnot—the Quai de la Loire and the Quai Fournier—were repaired. At the south end of the Quai de la Loire the demolition charges had failed to burst the wall, but had moved it out bodily a few inches. It was therefore strengthened by means of a series of pairs of 1¾-in. diameter tie rods, each 50 ft. long and placed at 50-ft. intervals, each pair being anchored in a buried concrete block and retaining the quay wall by a plate 3 ft. long and 6 in. high welded to the ends of the rods.

Some repairs were carried out to the Bassin à Flot de l'Ouest, to permit coasters to berth. The swing bridge was turned by means of jacks; the lock gates, although jammed with debris, were in working order. The craters in the south quay wall were repaired and the berths dredged to 8 ft. below chart datum. Other works carried out at Calais included the bridging with timber of three craters in the Jetée d'Est (a concrete breakwater with a timber superstructure); the reconstruction of a timber jetty in the Avant Port; the lighting of the Gare Maritime; and the construction of a made-up area for use as a vehicle park. The total number of military man-hours expended at Calais up to March 31, 1945, was over 412,000.

It will be clear from the description we have given of the emergency repairs to Dieppe, Boulogne, Calais and Ostend, that it is possible to restore ports that have been extensively damaged by bombing and demolitions, sufficiently for military purposes, in a comparatively short time, and largely by the use of materials found locally. Nevertheless, the major permanent repairs remained to be done, and were, of course, left to the civilian authorities.

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WAR DAMAGE AND REPAIRS AT CALAIS.

Fig. 25. Entrance and South-West Side of Calais Port.

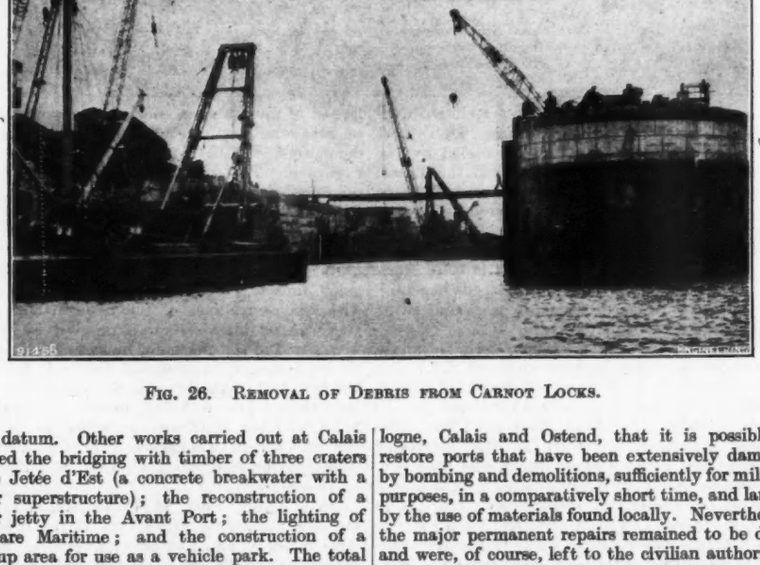


Fig. 26. Removal of Debris from Carnot Locks.

LITERATURE.

Test Papers and Solutions on Electrical Engineering. By DR. T. F. WALL. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 25*s.* net.]

THIS book forms the companion volume to Dr. Wall's previously published *Principles of Electrical Engineering*, a work of degree standard covering both the light- and heavy-current aspects of the subject and laying emphasis on underlying principles. A text owing its clarity to the hard labour of its author is liable to lull the student into the belief that he can grasp its implications through mere reading, but lack of success in working out problems speedily corrects this impression. Knowing this, the experienced teacher will arrange for his students to work through plenty of suitably graded examples. Ample scope for this means of checking progress is afforded by Dr. Wall's comprehensive and carefully selected set of test papers, with solutions. The problems are thoroughly representative, of real interest, and of a suitably varied character. The majority supply effective illustrations of general principles and many serve as the basis of important practical applications which are duly noted. The greater number are quantitative, but a few are descriptive. Some are based on results derived in, and quoted from, the parent volume. Others are self-contained, while a few extend somewhat beyond the ground covered in the original text. Several develop out of Dr. Wall's original contributions to ENGINEERING and other technical journals.

The following are among the more important, in the order in which they are treated. The first set of questions deals with fundamental and technical units. This is followed by a number on electrolysis, the heating effects of currents, conduction of electricity through gases, thermionic tubes and the electric arc. It may be noted that opposite conventions are used to indicate the polarity of a cell in Fig. 2, on page 8, and in Fig. 9, on page 15. An extra line is needed at the top of page 28 to show that the value found for R_x does, in fact, make W_x a maximum. The two chapters on electrostatics contain examples on earth currents, force and potential and calculations of capacitance, chosen for their practical importance. The evaluation of the capacitance per phase of a symmetrically-disposed three-phase transmission line brings out clearly the significance of the "potential coefficients." In the section on current distributors and networks, the "siemen" is used as the unit of conductance in place of the more usual "mho." The purpose of the dotted line in the determinant on page 64 is not explained. The examples on thermo-electricity and piezo-electricity are of particular interest.

A chapter on magnetism and magnetic measurements is followed by one on electromagnetism that includes the calculation of the trajectories of an electron subject to the joint action of mutually perpendicular electric and magnetic fields. Adequate practice in the manipulation of complex quantities is provided in the problems on alternating currents and in the more complicated problems presented by coupled oscillating circuits. A set of examples on alternating-current power is followed by a useful section on graphical methods, based largely on the inversion transformation. A section devoted to non-sinusoidal wave forms and their influence on electrical measurements includes an example of the harmonic analysis of a periodic wave form, in which a fuller explanation of the method used would be helpful. The penetration of alternating magnetic flux and high-frequency alternating currents (the skin effect) is next considered. The two concluding chapters deal with the propagation of electrical energy along transmission lines and cables, and the propagation of electromagnetic waves through space, and include examples relating to high-pass, low-pass and band-pass filters. There are a number of misprints, but usually these are sufficiently obvious.

Straightforward standard methods of solution are employed throughout. Nearly all the solutions are models of clarity and conciseness, qualities to be particularly commended to the student preparing for professional examinations. To the users of Dr. Wall's *Principles of Electrical Engineering* this companion volume will prove of particular value, but especially to the student who is compelled to rely to a large extent on his own resources.

Macromolécules. Volume 1. *Physique et structure des Plastiques.* By PROFESSOR P. PIGANIOL. Collection Matériaux de Synthèse. Dunod, 92, Rue Bonaparte, Paris VIe. [Price 760 francs.]

FIVE volumes of the *Collection Matériaux de Synthèse* have been published so far. The present volume, on the Physics and Structure of Plastics, is contributed by the director of the series, who states that he has in preparation a companion volume dealing with the Chemistry and Synthesis of Plastics. In his preface, Professor Duclaux, of the Collège de France, contributes some outspoken comments on the conservatism of universities, where, even now, courses bearing directly upon the physics and chemistry of plastic materials are rarely offered. In this field, Carlyle's dictum that the true university is a collection of books, is, perforce, true, and it is the aim of this series to supply such a collection. The task that Professor Piganiol has set himself is to provide a broad general survey of the scientific basis of the subject, leaving its more technical aspects to be dealt with in greater detail in existing, or forthcoming, volumes of this series.

The first part of the book, under the title of "Structure of Matter," is more especially concerned with the structure of organic molecules and with the various forces acting between them. It includes an important chapter on compounds of high molecular weight, the polymers consisting of aggregates of monomers, and the polycondensation products, the molecular formulæ of which differ from those of the corresponding monomers. Such synthetic materials are rarely homogeneous, usually consisting of mixtures of molecules of similar structure but of various degrees of complexity. The physical properties of a complex of this sort will depend on the relative proportions in which these different constituents are present in it. These may be specified in terms of molecular characteristics or coefficients of heterogeneity. Some of these giant molecules are comparatively compact structures, others consist of long chains. The linkages being largely random, and the chains of unequal length, an attempt has been made to apply statistical arguments to such molecules in solution. This first part concludes with a short appendix in which the essential ideas of this method of approach are outlined.

The second part of the book is devoted to the behaviour of macromolecules, as revealed by physical agencies. The scope and limitations of ordinary and electron microscopy are pointed out and the use of X-ray diffraction techniques for investigating the crystalline structure or amorphous character of plastic materials is described, with illustrative examples. A chapter is devoted to the action of solvents on macromolecular compounds which is complicated by the swelling that so often accompanies it. The progressive addition of a non-solvent to a macromolecular solution enables fractions of decreasing molecular weight to be precipitated and it is shown that, by such means, and on the basis of certain assumptions, molecular weights and molecular characteristics can be determined. A useful summary is given of various other methods that have been applied for determining molecular weights. Among them are those based on the measurement of the osmotic pressure of a solution, the rise in the boiling point or the lowering of the melting point of a solution, diffusion observations, viscosity measurements, optical and electrical phenomena. The many technical problems encountered and overcome in the construction and operation of the ultra-centrifuge by Svedberg and others are very clearly discussed. Only brief consideration is given to the physical properties of plastic materials and the action of plasticisers in the two final chapters, since these subjects are to be dealt with more fully in subsequent volumes. There are a number of missing or misplaced letters and symbols; Stokes is given as "Stockes" on two occasions, and the expressions for force and potential on page 12 have become transposed.

A valuable feature of Professor Piganiol's text is its critical outlook. Many of the methods available at present rest on slender theoretical foundations or are based on over simplifying assumptions. The first step towards remedying these defects is to have them pointed out clearly, as he has done.

Aerodynamics. By PROFESSOR LESLIE R. PARKINSON. The Macmillan Company, New York, U.S.A. [Price 2.20 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 11*s.* net.]

THE study of aerodynamics becomes more difficult as each new advance takes place, and the non-specialist must of necessity find this growing complexity a barrier to a proper understanding and appreciation of what really occurs during flight; it is to assist the non-specialist that this book has been written. It attempts, not quite successfully, to prune the subject with a view to making the fundamentals available to its potential readers in a form in which they can be readily assimilated. Starting with the elementary processes of mechanics as applied to fluid motion, the author covers a wide range of material, including chapters on such items as airfoils, lift-increasing devices, performance, stability, propellers and wind tunnels. Each of these is dealt with from a very elementary standpoint which, while of restricted value to those who would expect to utilise their knowledge of the subject, may be of use to those engaged in occupations where a little knowledge is desirable and may not be a dangerous thing. The reader requires little in the way of mathematical background—a desirable feature in view of the scope of the book, but one which may convey a somewhat erroneous impression to the uninitiated.

There is a distinct lack of balance in the relative amount of space allocated to some of the chapters. Thus the chapters on high-lift devices—which might have been written a long time ago—occupies the same space as that allocated to the whole of performance, including flight testing. To devote a mere ten pages to the latter is pruning to the extent of cutting away the roots. On the dust cover, the book is referred to as "up-to-date" which it certainly is not, and the claim that "what is known on the important subject of dynamic stability is reviewed" will hardly be supported by readers knowing anything of the subject.

ELECTRICITY-SUPPLY MAPS.—Two useful maps have been issued by *Electrical Industries*, 23, Great Queen-street, London, W.C.2, the first of which delineates the areas of the authorised electricity distributors, different colours being employed according to the output. The consumption per head of population is also indicated by different forms of hatching. Insets on a larger scale are provided for the London district and for an area roughly covering Derbyshire, the West Riding of Yorkshire and East Lancashire. The second map gives the positions of the selected stations and their interconnected grid lines in relation to the new Electricity Areas. Being printed on tracing cloth it enables the areas into which existing undertakings fall to be ascertained when it is placed over the first map. Separate units for the London and Manchester areas are given.

FLUORESCENT LIGHTING ON OMNIBUS.—An omnibus equipped with fluorescent lighting has been put into service by the Nottingham Corporation. For this vehicle, the General Electric Company, Magnet House, Kingsway, London, W.C.2, provided 23 15-watt warm-white lamps, each of which is totally enclosed in a reeded Perspex diffusing cover with opal ends. The average illumination obtained is over 12 lumens, which is between two and three times that provided in a modern installation using tungsten lamps. The necessary auxiliary gear has been made as small as possible and is fixed behind each fitting, either between the lining and the outer shell of the omnibus or on pattresses. The operating current is obtained from a 24-volt battery through a motor-generator, which runs at 8,000 r.p.m. This set was manufactured by C.A.V., Limited, Acton, London, W.3, and has a three-phase output of about 400 watts at 100 volts and 400 cycles per second. It is cooled by a self-contained fan and is suspended on rubber in a soundproof container. The complete unit is only 15 in. long overall and 11 in. in diameter, and weighs 30 lb. All the switching is carried out on the low-voltage side.

MOVING LOADS ON CONTINUOUS BEAMS.

By J. J. O'Donovan, B.Sc.(Eng.), A.M.I.C.E.I.

The problem of the continuous beam is statically indeterminate, that is, it cannot be solved by the methods of simple statics. When a beam is continuous over two spans, it has one redundant condition; when continuous over three spans, it has two redundant conditions, and so on, each additional span introducing another redundant condition. Numerous methods of finding the reactions and the bending moments over the supports, due to static loading, are given in books on the theory of structures. Those most used, until recently, were, probably, Clapeyron's Theorem of Three Moments—an "exact" method; and the Method of Characteristic Points—a graphical method. It will usually be found that the text-books give very few notes on the subject of moving loads on continuous beams, confine themselves to the case of two spans only with supported ends, and recommend working from the deflection curve obtained when the central support is removed.

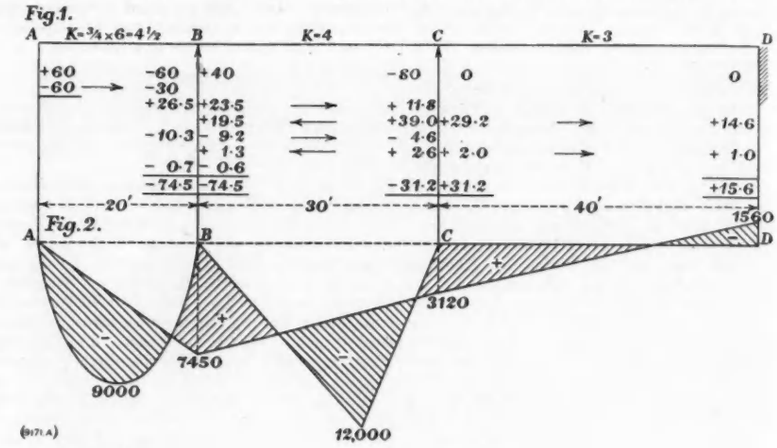
Many engineers, who are accustomed to drawing influence lines for beams and open-web trusses supported at their ends, using an equation for shear force or bending moment, as the case may be, find it difficult to visualise the procedure when, for the case of the continuous beam, they have to work from the deflection curve, and accordingly they prefer the graphical method. Professor Hardy Cross's Method of Balancing Moments or Moment Distribution, is being used more and more for the solution of the problem of the continuous beam under static loading, and, as will be shown, it can be easily extended to cover the case of a moving load also.

As Professor Hardy Cross's method is a comparatively recent one, knowledge of which has not spread as it deserves, owing to the war, an example may be given of its application to the case of a continuous beam, A B C D, Fig. 2, of three spans, A B, B C and C D, of 20 ft., 30 ft., and 40 ft., respectively with the end A pinned and the end D fixed horizontally. A B carries a uniformly-distributed load of 180 lb. per foot run over the whole span; B C carries a load of 1,800 lb., concentrated at 20 ft. from B and 10 ft. from C; and there is no load on C D. The supports are assumed to be at the same level; and the value of E I is assumed constant.

The first step is to imagine the joints fixed horizontally, and to calculate the end moments for each span considered as a beam fixed at its ends. A special convention is used, in accordance with which the sign is taken as positive if the end moment tends to rotate the adjacent joint in a clockwise direction, and negative if the tendency is to cause rotation in a counter-clockwise direction. (According to this sign convention, a horizontal beam carrying a vertical downward load has a positive moment at the left-hand, and a negative moment at the right-hand end.) The end moments are found to be, in lb.-ft., at A, + 6,000; at B, to the left, — 5,000; at B, to the right, + 4,000; at C, to the left, — 8,000; at C, to the right, 0; at D, 0. These are written down as in Fig. 1. (For convenience, the values have been divided by 100.)

The next step is to imagine the joints to be successively released and refixed, one by one, into new positions as many times as may be considered necessary until, finally, each joint has rotated into its proper position. At the end A, there is a moment of + 60; but, as A is pinned, the moment there should be zero. To make the moment zero, place — 60 at A, and draw a line beneath to indicate that A is balanced. When the end A, of A B, is released, the angle change at the far end, B, is one-half of that at A. To fix B, or to rotate it backwards to its original position, it is necessary to place, at B, one-half of the moment applied at A, in this case — 30. There is now, at B, — 90 to the left and + 40 to the right. It is obvious that we cannot have two different values of the bending moment at a joint; B is unbalanced by — 50, and + 50 must be distributed at B to balance that joint.

Now, when a load may be transferred from one point to another in a structure over two or more paths of unequal flexibility, the load will be divided over these paths in proportion to their relative flexibility. The amount of + 50 at B must be shared, therefore, between the members A B and B C in proportion to their stiffness factors, $\frac{I}{l}$ (usually denoted by K). The ratio of the values of K for A B, B C and C D is $\frac{1}{6} : \frac{1}{9} : \frac{1}{12}$ or 6 : 4 : 3. But the end A is pinned, D is fixed, and the beam is continuous over B and C. Now the ratio between the end rotations of two identical beams, one of which is pinned and the other fixed or continuous, is as 4 : 3. The value of K, obtained as above, is therefore multiplied by $\frac{3}{4}$, and A is considered as definitely pinned so that no moment can be transferred there. The values of K are now $4\frac{1}{2} : 4 : 3$ for A B, B C and C D, respectively. The amount of + 50, to be applied at B, is distributed in the ratio $4\frac{1}{2}$ to the left and 4 to the right; that is, + 26·5 is put to the left and + 23·5 to the right, balancing B. When + 23·5 is put to the right at B, one-half of this, namely, + 11·8, must be transferred to the right at C. This gives — 68·2 to the left at C and 0 to the right; so we distribute + 68·2 at C in the ratio 4 : 3, that is + 39·0 to the left and + 29·2 to the right, balancing C and carrying + 19·5 to B and + 14·6 to D. C is now balanced, but B is unbalanced; so — 10·3 is put to the left at B and — 9·2 to the right, carrying over — 4·6 to C. No moment is carried to A because this point is definitely pinned. B is now balanced, but C is unbalanced; so + 4·6 is distributed at C. C and B are then balanced successively until the amount to be distributed is no longer appreciable. It will be noted that the moment at the fixed end D, is never balanced. This is because its true condition is fixed, and it cannot be unlocked and allowed to rotate. If the beam be imagined to be continued beyond D, as in a mirror, with spans similar to and



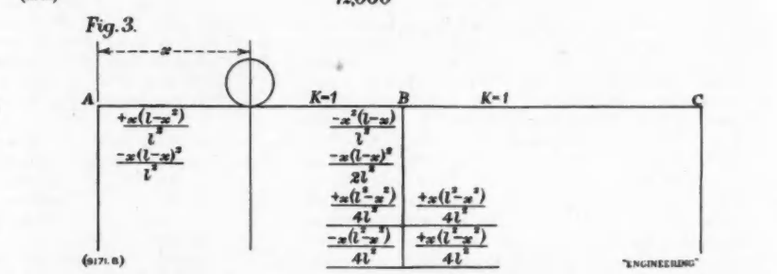


TABLE I.—Two Spans: Both Ends Pinned.

Value of x.	0·1.	0·2.	0·3.	0·4.	0·5.	0·6.	0·7.	0·8.	0·9.
M_B	0·0248	0·0480	0·0683	0·0840	0·0938	0·0960	0·0893	0·0720	0·0428
M_X	0·0875	0·1504	0·1895	0·2064	0·2031	0·1824	0·1475	0·1024	0·0515
R_A	0·8753	0·7520	0·6318	0·5160	0·4063	0·3040	0·2108	0·1280	0·0573
R_B	0·1495	0·2960	0·4365	0·5680	0·6875	0·7920	0·8785	0·9440	0·9855
R_C	—0·0248	—0·0480	—0·0683	—0·0840	—0·0938	—0·0960	—0·0893	—0·0720	—0·0428

Value of x.	1·1.	1·2.	1·3.	1·4.	1·5.	1·6.	1·7.	1·8.	1·9.
M_B	0·0428	0·0720	0·0893	0·0960	0·0938	0·0840	0·0683	0·0480	0·0248
M_X	0·0515	0·1024	0·1475	0·1824	0·2031	0·2064	0·1895	0·1504	0·0875
R_A	—0·0428	—0·0720	—0·0893	—0·0960	—0·0938	—0·0840	—0·0683	—0·0480	—0·0248
R_B	0·9855	0·9440	0·8785	0·7920	0·6875	0·5680	0·4365	0·2960	0·1495
R_C	0·0573	0·1280	0·2108	0·3040	0·4063	0·5160	0·6318	0·7520	0·8753

TABLE II.

Value of x.	0·1.	0·2.	0·3.	0·4.	0·5.	0·6.	0·7.	0·8.	0·9.
$(a - x)$	0·3	0·2	0·1						
$R_A . a$	0·3501	0·3008	0·2527	0·2064	0·1625	0·1216	0·0843	0·0512	0·0229
M_P	—0·0501	—0·1008	—0·1527	—0·2064	—0·1625	—0·1216	—0·0843	—0·0512	—0·0229

Value of x.	1·1.	1·2.	1·3.	1·4.	1·5.	1·6.	1·7.	1·8.	1·9.
$M_P = -R_A . a$	0·0171	0·0288	0·0357	0·0384	0·0375	0·0336	0·0273	0·0192	0·0099

MOVING LOADS ON CONTINUOUS BEAMS.

Fig. 4.

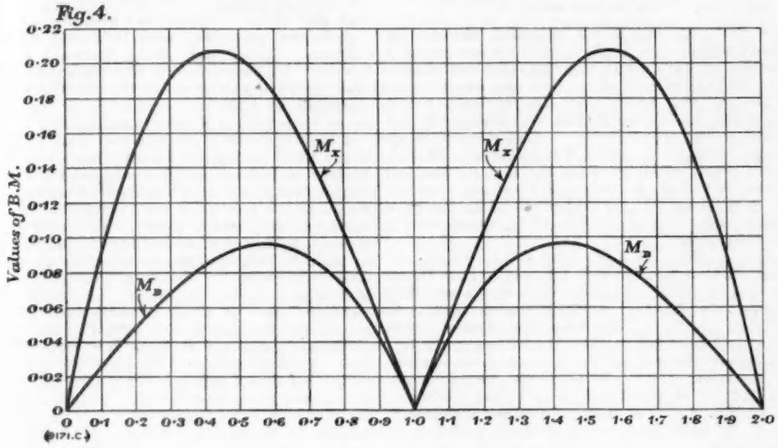


Fig. 5.

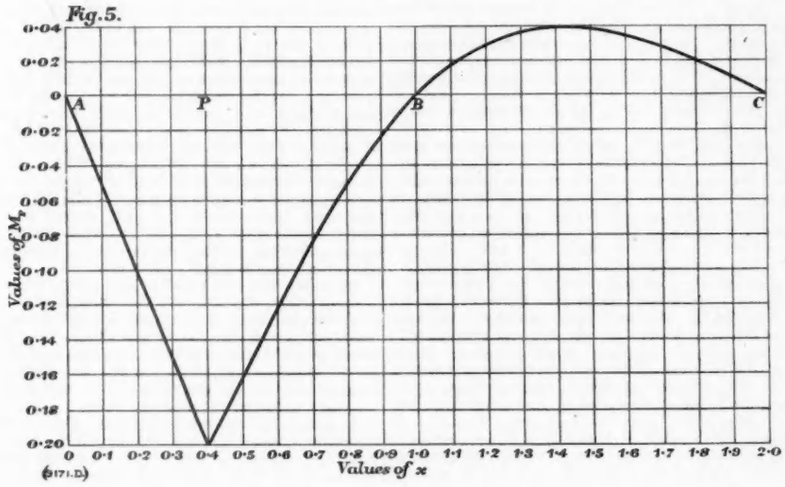
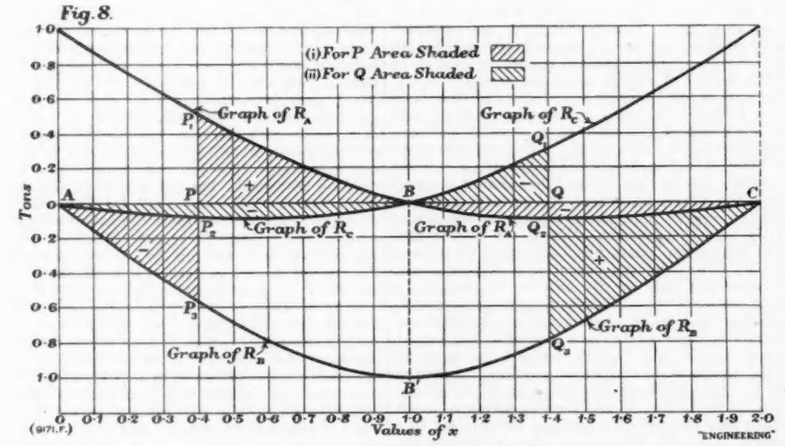


Fig. 8.



carrying the same loads as D C, C B and B A, respectively, the same values would be obtained to the right as to the left of D; in other words, D is balanced.

Totalling and multiplying by 100, it is found that $M_A = 0$; $M_B = \pm 7{,}450$; $M_C = \pm 3{,}120$; and $M_D = +1{,}560$. Reverting to the ordinary sign convention, in accordance with which bending that causes convexity upwards is positive, the bending moments at B and C are found to be positive while that at D is negative. This is borne out by the fact that the sign, to the left, at D, is positive instead of negative as in the case of B and C. The bending-moment diagram for the beam will then be as in Fig. 2, opposite. It may be noted that, since there is no load on C D, $M_D = -\frac{1}{2} M_C$.

The following are some typical examples of moving loads on continuous beams, with supports at the same level.

Case I.—*Continuous Beam of Two Equal Spans, with Ends Supported or Pinned and Value of E I Constant.*—Let a unit load be at X on A B, at x from A and $(l - x)$ from B. Then, if A B were fixed at its ends, we should have $M_A = +\frac{x(l-x)^2}{l^2}$, and $M_B = -\frac{x^2(l-x)}{l^2}$ (see Fig. 3, opposite). Since the two spans are identical, the values of K are equal.

Fig. 6.

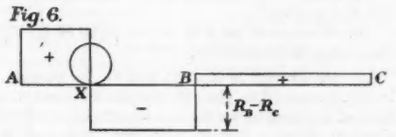
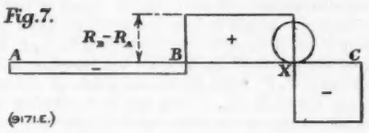


Fig. 7.



Any moment placed at B, therefore, must be distributed equally to the right and to the left.

The calculations are worked out in Fig. 3, and show that $M_B = \frac{x(l^2 - x^2)}{4l^2}$.

$$R_A = \frac{l-x}{l} + \frac{M_A - M_B}{l} = \frac{(l-x)(4l^2 - lx - x^2)}{4l^2}$$

$$R_B = \frac{x}{l} + \frac{M_B - M_A}{l} + \frac{M_B - M_C}{l} = \frac{x(3l^2 - x^2)}{2l^2}$$

$$R_C = 0 + \frac{M_C - M_B}{l} = -\frac{x(l^2 - x^2)}{4l^2} \text{ (downwards).}$$

Differentiating and equating to zero for a maximum, the maximum B.M. at B $= 0{\cdot}0962l$, occurring when the load is at $0{\cdot}577l$ from A or at $0{\cdot}577l$ from C. When the load is at X on AB, at x from A, $M_X = R_A x$. Differentiating and equating to zero, the maximum B.M. under the load $= -0{\cdot}2092l$, occurring when the load is at $0{\cdot}4323l$ from A or C. This bending moment tends to cause convexity downwards and is therefore negative. It will be seen that the greatest value of the bending moment which can occur on the beam is $-0{\cdot}2092l$ and occurs under the load when the load is at $0{\cdot}4323l$ from A or C, and that it tends to cause convexity upwards.

Values of the bending moments at B and X, and of the reactions at A, B and C, are given in Table I, opposite, and the values of the bending moments at B and X are plotted in Fig. 4, on this page. The bending moment at B is positive, while that at X is negative; but for convenience, both are plotted on the same side of the base-line. The graph of the bending moment at B is, in effect, an influence line, and therefore may be used to find the bending moment at B due to a series of point loads, or to a uniformly-distributed load over the whole or part of the span. The minus signs before the values of the reactions at A and C, in Table I, indicate that these act downwards. The values of x are measured from the left-hand end A.

If it be required to draw an influence line for the bending moment at a point P, on A B, at a distance a from A and b from B: it is found that, when the load is at x from A and to the left of P, $M_P = l(a - x) - R_A a$; and, to the right of P, $M_P = -R_A a$. Values of the reaction at A can be found from Table I, and the influence line plotted. If, for example, P be at $0{\cdot}4l$ from A on A B, and the span be of unit length, values are obtained as in Table II, opposite. These values are plotted in Fig. 5, on this page.

To obtain the influence line for shear force at a point, it is necessary to consider two cases, namely, when the point is on A B, and when the point is on B C. Let the point on A B be P, and the point on B C be Q. If a load is applied at X on A B, then, beginning at the left-hand end, A, laying off the value of the reaction at A above the line, the ordinary shear-force diagram for the beam will be as in Fig. 6, on this page; and, when the load is on B C, the diagram will be as in Fig. 7. If the portion of the diagram above the base-line be considered as positive, and the portion below the base-line as negative, then we have:—

(*a*) P on A B—(i) When the load is on A B, to the left of P, $F_P = R_B - R_C$, and is negative.

(ii) When it is to the right of P, $F_P = R_A$, and is positive.

(iii) When the load is on B C, to the right of P, $F_P = R_A$, and is negative.

(*b*) Q on B C—(i) When the load is on A B, to the left of Q, $F_Q = R_C$, and is positive.

(ii) When it is on B C, to the left of Q, $F_Q = R_C$, and is negative.

(iii) When it is on B C, to the right of Q, $F_Q = R_B - R_A$, and is positive.

Let the graphs of R_A, R_B and R_C be plotted as in Fig. 8, page 485. Here the graphs of R_A and R_C are plotted above or below the base-line to agree with the signs in Table I, but R_B is drawn below the base line, although all values of R_B are shown as positive in Table I. If the influence line be required for a point P on A B, draw the vertical lines P_1 P, from P_1 on the graph of R_A to P on the base line A B C, and draw P_2 P_3 from P_2 on the graph of R_C to P_3 on the graph of R_B. Then the areas shaded with lines sloping upwards to the right will give the values of the shear force at P. Thus, when the load is to the left of P, $F_P = R_B - R_C$, and is negative; when the load is on A B to the right of P, $F_P = R_A$, and is positive; and when the load is on B C, $F_P = R_A$, and is negative. Similarly, if the influence line is required for the point Q on B C, draw the lines Q_1 Q and Q_2 Q_3. Then the areas shaded with lines sloping downwards to the right will give the values of the shear force at Q. The shaded areas in Fig. 8 are given positive and negative signs to correspond with Figs. 6 and 7.

(*To be continued.*)

DIESEL-ENGINED ELECTRIC WELDER AND COMPRESSOR.

A COMBINATION unit, consisting of a Diesel engine driving two direct-current generators and a two-stage air compressor on the same shaft, has recently been designed by Murex Welding Processes, Limited, Waltham Cross, Hertfordshire, for the repair of the machinery used in open-cast coal operations. As, however, it provides facilities not only for arc welding, but for the operation of electric machine tools, pneumatic hammers and paint and metal sprayers, as well as for floodlighting and inspection lamps, it obviously has wider applications.

The Diesel engine has an output of 34 h.p. when running at 1,500 r.p.m. It is cold starting, and preheating ignition cartridges or glow plugs are, therefore, unnecessary. Its fuel consumption is given as 0·39 pint per brake horse-power hour. The welding generator, which has an output of 9 kW, is of the self-stabilising type and has been specially designed for arc welding. The current can be varied from 15 to 300 amperes at 30 volts by combined series and shunt control, the open-circuit voltage being about 70. The controls are mounted in a cabinet, built over the generator, and include a thirty-stud regulator for fine current adjustment over each range, a large-scale ammeter and voltmeter, and one negative and three positive welding terminals. The auxiliary direct-current generator has an output of 2 kW at 220 volts, and is controlled by a switch fuse. It is connected to a power socket for tools and to another for lighting. The air compressor, which has an output of 31 cub. ft. of free air per minute at a pressure of 100 lb. per square inch, is coupled to the auxiliary generator through a dry-plate disc clutch so that it can easily be disconnected when not required. It is fitted with an air-intake filter, constant-speed unloader, air-cooled inter-stage cooler, and is connected to an air receiver. This receiver is 36 in. long by 24 in. in diameter, and is fitted with two hand holes and covers, safety and drain valves, pressure gauge and two 1-in. outlet valves. It is welded throughout and afterwards heat-treated and tested to twice the working pressure.

The whole unit is mounted in line on a fabricated bedplate and is covered with a canopy in which there are six sliding doors. The accessories include a radiator-fan, silencer and ten-gallon fuel tank. A fuel-level indicator, re-fuelling pump, tool boxes and cable reel can also be fitted. The original equipment was built for transportation in a lorry, but it is suitable for mounting on a high-speed pneumatic-tyred trailer.

SHEET AND STRIP METAL USERS' TECHNICAL ASSOCIATION.—A special meeting of the Sheet and Strip Metal Users' Technical Association has been arranged for Wednesday, December 3, at 6.15 p.m., at the Queen's Hotel, Birmingham, when a paper by Mr. W. H. R. Bird on "Technical Developments in the Manufacture of Improved Sheet Steel" will be read. The attainment of "full finish" or "autobody" surface will be discussed. Non-members are invited and tickets of admission are obtainable from the secretary of the Association, 49, Wellington-street, London, W.C.2.

THE EARLY HISTORY OF PATENTS FOR INVENTION.*

By M. FRUMKIN.

ON the Continent, it was generally believed that patents originated in England and were introduced in other countries at a very late period as a mere imitation of an old English institution. Such also was the belief of Goethe, who wrote that the invention patent "originated among the English who draw profit and advantage out of everything." That state of things changed when E. W. Hulme, former librarian of H.M. Patent Office, began to study the subject; and his papers, the first of which appeared about half a century ago, have served not only as the basis of the history of English patents, but also as a model for investigators in other countries.

More progress was made after 1900. Hulme continued his most valuable work, followed by D. S. Davies and by A. A. Gomme, his successor at the Patent Office Library. In America, excellent studies have been published by Price, Frederico and Prager, while Picard and Isoré have tackled the subject in France; in Germany, Hofman and Meldau made many interesting discoveries. During the recent war, a most remarkable study of old Netherlands patents was published by G. Doorman, a work of unprecedented size and elaboration.† In Italy, Professor G. Mandich published, in 1936, the amazing results of his research in the archives of Venice. The first patents in Italy and the first patent applications by Italians abroad are of a singular importance: up till now, our views on the origin of patents have had to be revised from time to time, following the discovery of still earlier privileges, but now the rock bottom seems to be reached, and it is unlikely that older patents, not to say patent systems, will be discovered.

Patents can originate only when inventions are made—a simple truth forgotten by some investigators—and when their inventors are able to exercise pressure on the State by soliciting privileges for their work. In antiquity, useful inventions were so rare that they could not create any custom of granting privileges, which would later give origin to a law. The rare inventors were either slaves, the only class occupied in mechanical arts, or philosophers, too proud or too detached to seek material profit. Plutarchus praises Archimedes for not describing his practical inventions, these belonging to an "art vile, low and mercenary"; and the term of "engineer" could be used in Greece as a term of abuse. This contradicts what has been so often said, by Francis Bacon, among others, about inventors being so honoured in Antiquity that they have been made gods or demi-gods. The idea of progress did not exist in Antiquity, a fact as certain as it is difficult to realise. Greek mythology gives an excellent proof of that assertion: the ideal state of the Golden Age gradually deteriorates, passing into the Silver Age, followed by the less happy Bronze and the dismal Iron Ages. This is the very reverse of the idea of progress, and has an utmost importance for the study of this subject, a patent system being nothing else but the idea of progress appearing in law.

The men of the following period also had their faces turned towards the past, and science or philosophy were not expected to attain the level which had been reached at the time of Aristotle. The material world was viewed as fundamentally bad and unsafe, even liable to complete destruction (witness the scare of the year 1000); the only improvement was to be expected in the other world. This means again, few inventions and no invention patents. During the earlier part of that period, the "Dark Age," the arts of Greece and Rome vanished from the greater part of Europe and were preserved only in the Eastern Empire. It is quite likely that the modern monopoly originated in Byzantium, and became the invention patent at the Renaissance, when inventions appeared in numbers.

A traveller of the Twelfth Century, Benjamin of Tudela, mentions an exclusive privilege for dyeing cloth in the semi-Byzantine kingdom of Jerusalem. An annual fee had to be paid for that privilege, which included also the use of a building suitable for that industry. The next privilege, granted in 1236 by the mayor of Bordeaux to an inhabitant of that city, and confirmed by the King of England, then also Duke of Gascony, gave an exclusive right for the term of 15 years to make cloth following Flemish or English methods. This is a patent-like grant, but not a patent in the modern sense, as no specific invention is involved.

Later, Edward III, wishing to attract Flemish weavers to England—as the country would make more profit by exporting woollen cloth rather than raw wool—began in 1331 to give them "letters of protection." These letters, somewhat similar to a modern passport (or visa) did not confer any exclusive privilege. Indeed, they were not connected with any invention, did not create a monopoly, and were not limited in time. The Plantagenets certainly did not tempt the Flemings with any exclusive rights, but with the promise of "good beer, good beef, good beds, and still better company, English girls being renowned for their beauty." This seems to have been much more effective than any monopoly clause, as the Flemish cities were compelled to make an agreement to prevent the excessive emigration of weavers to England.

A most remarkable privilege was issued in 1449 by Henry VI to a foreigner, John Utynam, who came to England to make stained-glass windows for the chapel of Eton College and other buildings. The grant corresponds, not to a modern invention patent, but to what is called an "importation patent," which still exists in Belgium, Spain and many republics of South America. In 1449, the making of stained glass, though not practised in England, had already three or four centuries of existence on the Continent. In France, several privileges, some of them exclusive, had also been granted for glassmaking. In 1330, Philippe VI, King of France, authorised Philippe de Cacqueray (called later "the first inventor of flat glass") to set up glass works; an annual payment of 3 pounds or 20 bushels of oats had to be made for that privilege. In 1453, the Count of Eu, a prince of royal blood, granted Antoine de Brossard an exclusive privilege for glass-making in his county.

Some of these ancient grants have a fairly modern appearance, but it would be rash to say that they were patents for inventions. Very often the privileges aimed, not at the encouragement of an industry, but at its restriction. Such was the case of the French glass patents; and the reason for that was the fear that too many works would lead to the destruction of forests, as wood and charcoal were the main kinds of fuel used. Even later, when "sea-coal" began to replace charcoal, special laws restricted in Elizabethan England the iron industry for the same reason. Privileges for other arts imported from abroad may be explained by the fact that work outside the guild system was then impossible to imagine, and the privileges amounted to nothing but the creation of new guilds, consisting at first of one master only.

The term "Middle Ages" is used to denote a certain state of affairs which, in the Fourteenth and Fifteenth Centuries, certainly did not exist in Italy, and particularly in the two Italian republics of Florence and Venice, which were then the most brilliant centres of civilisation in the western world. Florence was then the financial centre of Europe and also the seat of a very important woollen industry. Florentines were not artistic Bohemians, but eminently practical people. Consequently we are not surprised to find that, in 1406, three Lombard artisans made a contract with the powerful Florentine wool guild to the following effect: the Lombard artisans would produce various metal tools for the textile industry (particularly metal cards) and teach their methods, but, during a term of three years, their pupils must not produce the tools without their consent. In 1409, at the expiry of their privilege, the three Lombards were granted other privileges for 20 years, such as exemption from taxes, freedom from guild control, etc. This was probably not an isolated case, as, in 1421, Florence created the offices of the *consules maris*, whose main function was to introduce new industries. Here Florence seems to have followed the lead of Venice; but the next step, and the most important one, was made again by Florence. In the same year, 1421, the first invention patent was granted; a real invention patent, as good in subject-matter as any of those dealt with in 1947 by the Patent Office. Present-day patentees need not be ashamed of their ancestor: he was Brunelleschi, the earliest modern architect. The patent was granted for three years only. The object of Brunelleschi's patent was a kind of barge with hoisting gear, which he used successfully for the transport of marble needed for his buildings. It does not seem that a patent system followed in Florence from that first grant, and it is certain that, after 1450, the primacy in that respect passed to Venice, where it remained for about a century.

(*To be continued.*)

* Paper presented at a joint meeting of the Chartered Institute of Patent Agents and the Newcomen Society, held in London on November 12, 1947. Abridged.

† Reviewed in ENGINEERING, vol. 161, page 340 (1946).

INSTITUTION OF MECHANICAL ENGINEERS.—The next associate-membership examination of the Institution of Mechanical Engineers will be held at centres in this country, and in India and Ceylon, on Tuesday, April 6, to Friday, April 9, 1948. The common preliminary examination of the senior engineering institutions will be held simultaneously. For both examinations, the closing dates for the submission of entrance forms are November 30, 1947, for centres in India and Ceylon, and February 28, 1948, for centres at home. Entrance forms and further information are obtainable from the secretary, The Institution of Mechanical Engineers, Storey's-gate, St. James's Park, London, S.W.1.

THE INSTITUTION OF MECHANICAL ENGINEERS: PRESIDENTIAL ADDRESS.*

By Lord Dudley Gordon, D.S.O.

(*Concluded from page* 476.)

Compared with the iron and steel industry, that of refrigeration is almost a development of yesterday. Although, as early as 1834, Jacob Perkins had demonstrated the practicability of a refrigerating machine based on the principle of compressing ether, and such a machine was built at the time, refrigeration did not assume any commercial importance until many years after the Institution was founded. The subject was first brought before the members in 1881 by T. B. Lightfoot, who described machines (for producing cold air) which were then coming into use for the frozen-meat trade, brewing, etc. These machines worked on the cycle of a reversed Joule air-engine. Air was compressed to 50 lb. or 60 lb. per square inch by a steam-driven reciprocating compressor, cooled under pressure, and then, after being made to restore as much as possible of the work of compression (by expansion in another cylinder), it was finally discharged at a temperature of 80 or more Fahrenheit degrees below zero. In 1886, Lightfoot returned to the subject of refrigeration with a comprehensive account of the apparatus then in use, or previously invented, for ice-making. The systems considered included the evaporation of water in a vacuum—first attempted by Dr. Cullen in 1755, and subsequently improved by Carré, Harrison, Windhausen and others; the vapour compression process, with ether, ammonia and sulphur dioxide as the working substances, developed by Harrison, Pictet, and Linde; and the ammonia absorption process, first applied by Carré about 1858. Wood charcoal—called "vegetable black"—and silicate cotton were used for the insulation of cold stores, but the use of granulated cork was advocated at the meeting by Druitt Halpin, who had had experience of it in Germany. Charcoal was abandoned after it had been suspected of causing fires on board ship, and the employment of slag wool or silicate cotton became common until superseded by cork, which is now universally used. It was stated by Price Williams in the discussion that the experience of the P. and O. Company indicated that meat was better preserved by chilling than by complete freezing, but Lightfoot considered freezing to be necessary—a belief since proved to be mistaken. It was not, however, until 1900 that the first successful consignment of chilled meat was landed at Liverpool from the Argentine.

The cold-air machine had become virtually obsolete by 1912, when papers on "Vapour-Compression Refrigerating Machines" and "The Theory of Refrigerating Machines" were read before the Institution by J. W. Anderson and J. H. Grindley, respectively. Refrigeration practice was then almost entirely dependent on installations involving the use of ammonia, carbon dioxide, or sulphur dioxide; all of these were fully dealt with in the papers. It became evident that it would be of great benefit to the industry in general if the Institution would take steps to secure agreement with regard to several questions on which there was diversity of opinion or practice. The Council therefore appointed a Refrigeration Research Committee, under the chairmanship of the late Sir Alfred Ewing, with the primary duty "to consider and define a Standard in Refrigeration and its Units of Measurement." No greater authority could have been entrusted with the task, for Ewing's name is highly respected by refrigerating engineers for his book on *The Mechanical Production of Cold*.

The Committee presented a report in 1914, and recommended that the unit of refrigerating effect should be one calorie per second, or 342,860 B.Th.U. per day of 24 hours, under stated temperature conditions. This unit, however, has not been generally adopted by the industry, and performances are still often reckoned in "tons of refrigeration" per day, which means a rate of heat withdrawal equal to that required to freeze so many tons of water in the same time. Such a definition might refer to either the English or the American ton, and it is now more usual to give the duty of refrigerating plant in terms of B.Th.U. per hour under stated conditions of brine and cooling water temperature. The real value of the report lay in its appendices. The first of these included total heat and entropy charts for carbon dioxide, ammonia and sulphur dioxide, with tables of the properties of these substances and of the specific heat of calcium-chloride brine, all according to the best data then available. A second appendix by Ewing explained the refrigeration cycle with reference to the use of the charts. These charts and tables rendered great service to the industry for a number of years.

Apart from a short paper, in 1923, dealing with heat transmission, from ammonia gas, through the walls of steel pipes, the subject of refrigeration was next brought before the Institution in 1929 by the late H. J. Ward. That year may be regarded as the jubilee of the frozen-meat trade, for it was in 1879 that the steamer Strathleven, equipped with a Bell-Coleman cold-air plant, left Australia with a small cargo of frozen meat for London, and thus inaugurated an industry destined to become of immense importance, not only to the inhabitants of these islands but also to the great meat-producing countries overseas. The inventor of the plant was Joseph James Coleman, who patented his cold-air machine in 1877, and H. and J. Bell were a firm of meat importers, who had approached Coleman on the advice of Lord Kelvin. The growth of the frozen-meat trade will be gathered from the fact that the number of frozen carcasses imported into this country was only 400 in 1880. In 1927, the number of chilled or frozen carcasses imported was 14,985,786, besides more than 18 million bunches of bananas brought in refrigerated ships from the West Indies.

At the time the paper was read, less than 1 per cent. of the refrigerated ships employed cold-air machines; 80 per cent. were using carbon dioxide, and 18 per cent. used ammonia. To-day the proportions, expressed as percentages, are as follows: carbon dioxide, 69·5; ammonia, 21·5; Freon, 6·5; methyl chloride, 1·5; and steam jet, 1·0. The higher proportion of refrigerating installations using ammonia is due to the fact that, during the war period, many war-time standard ships for carriage of food were fitted with the type of installation which could be most rapidly procured; that was an ammonia refrigerating plant situated in a deck house, with cooling pipes fitted in the holds. With the return to more normal conditions, the proportion of carbon-dioxide machinery is again increasing. At the same time, two new refrigerants are appearing: Freon and methyl chloride. The great preponderance of carbon-dioxide machinery is not due to any higher efficiency, but rather to its greater safety and convenience on board ship. The same circumstances do not apply on land, where, for the larger commercial installations, ammonia is the most commonly used refrigerant.

During the discussion of Ward's paper, it was suggested that, if the refrigerating machine developed along similar lines to those of the steam engine, a turbine compressor would eventually be favoured. To this the author replied that "he personally thought it was quite reasonable to expect to see turbine compressors for high pressures, as their use for moderate pressures, with ammonia, was within sight." The analogy does not, in fact, hold good, and the turbo-compressor has made little progress in this country. It is, however, extensively used in the United States, particularly in the case of the larger air-conditioning installations, and, in his centenary lecture in 1947, W. A. Carrier expressed the opinion that its use would become increasingly more common.

Later, Dr. Mawson dealt with the multiple-effect and compound-compression cycles used for carbon-dioxide machines, and compared the results obtained in practice with those calculated from theory. It is an excellent exposition of the use and value of the Mollier entropy and total-heat chart. The same author, in 1931, dealt with the thermodynamics of mixtures of non-condensable gases with condensable substances, particularly the use of hydrogen with ammonia. The effect of the presence of air or other inert gases, with ammonia or carbon dioxide, on the performance of refrigerating machines using those refrigerants, was investigated. His conclusion, borne out by practice, was that the presence of air was detrimental, and much more so in ammonia than in carbon dioxide.

The refrigerating engineer is just as much concerned with keeping coldness when he has got it, as he is with machines for creating it in the first place. Hence the question of insulation of cold stores, etc., is a matter of great importance to him. Valuable information on the heat conductivities and densities of eleven different insulating materials used in refrigerating work was afforded by Dr. Ezer Griffiths in 1939. H. L. Jones reviewed the various designs of small automatic refrigerating machines for shops, etc., in 1940.

It has been recognised by steam engineers, ever since the days of James Watt, that the condensation of live steam on its entrance to the colder cylinder of a steam engine, and its re-evaporation during the exhaust stroke, constitutes a serious source of loss. Refrigerating engineers are faced with an analogous problem, for the vapours they employ become condensed on the cylinder walls during the compression stroke and re-evaporate during the suction stroke. This re-evaporation will obviously interfere with the entrance of fresh vapour, and consequently may have a decidedly prejudicial effect on the volumetric efficiency of the compressor. The matter was investigated by Dr. E. Giffen and E. F. Newley, who described, in 1940, experiments they had carried out on the volumetric efficiency of an ammonia compressor in the engineering laboratory of King's College, London. The efficiency was found to fall by about 20 per cent. as the condition of the vapour at the suction valve was changed from a superheat of 45 deg. F. to a dryness fraction of 0·75. As might be expected, the amount of condensation depended largely on the temperature of the cylinder walls.

The same volume of the *Proceedings* contains a report of the sub-committee appointed to review, in the light of more recent investigations, the data on refrigerants collated by the Refrigeration Research Committee in 1914, a quarter of a century earlier. The outcome of the work of the subcommittee has been to make available to the members, for a small charge, up-to-date charts of the properties of ammonia, carbon dioxide, sulphur dioxide, methyl chloride, and Freon, all in British units. In the new charts, total heat has been plotted against pressure instead of against entropy, and lines of constant volume have been added. Skew co-ordinates have also been avoided, for in spite of the careful explanation of them given in one of the appendices to the earlier report, they have never been attractive to practical men. The report terminates with a most admirable bibliography of the subject, distinguished from the customary bald list of references by the fact that the reader is told just what he will find if he looks up the publications referred to.

When I had the honour of delivering the Thomas Hawksley Lecture in 1942, my object was to consider the rise of the refrigerating industry and to give an account of the practice of the time with regard to the kinds of refrigerants and the type of machinery used. A description was also given of the various means used to ensure "dry compression" in ammonia compressors the benefit of which has already been referred to in previous papers. Since that date, we have had Dr. Oscar Faber's paper on "The Value of Heat, with Special Reference to the Heat Pump." The heat pump is, in fact, a refrigerating machine in which the useful work is done on the high-temperature side instead of on the low-temperature side: that is to say, heat may be pumped from the water in a river, which is thus cooled, and the heat rejected from the condenser or high-temperature side of the cycle is used for the central heating of a building or some similar purpose. In March, 1947, a paper was read by J. A. Sumner, describing the heat pump installed in the stores of the Norwich Electricity Department. This was given, together with a paper on "The Air Cycle Heat Pump," by T. J. Thomas. Finally, during the centenary celebrations, we had the lectures of W. A. Carrier, on "Air Conditioning Plant in the U.S.A.," to which I have already referred; of Dr. S. F. Dorey, on "Refrigeration"; and of Dr. Faber on "Air Conditioning, Heating, and Ventilating."

The refrigerating machine is essentially a reversed heat engine, and much of the reasoning which applies to one is equally applicable to the other. The ideal cycle of Carnot provides the absolute criterion of efficiency in both cases. We may not—indeed we do not—attempt to follow the cycle rigidly, because practical considerations have to be taken into account, but at least we know the effect of every departure from it. On the mechanical side also, refrigerating engineers had the advantage of the long experience previously gained by the makers of steam and hydraulic machinery, many of whose problems were analogous with those confronting the designers of the new machines. Hence the story of refrigeration cannot be expected to record any such revolutionary changes in practice or theory as have characterised some of the older branches of engineering. Apart from the general adoption of vapour compression in place of the cold-air system about 1890, progress has consisted for the most part in the steady evolution of definite types of machinery along lines indicated by experience.

Attention, however, should be drawn to a comparatively modern development of the industry brought about by a growing demand for small refrigerators for domestic use in the preservation of food and the making of ice. A vast amount of energy and ingenuity has been displayed in contriving such machines, which have to be reliable in the most unskilful hands, compact, pleasing in appearance, and saleable at a reasonable price. The modern applications of refrigeration, to air-conditioning or comfort cooling in living spaces, have resulted not only in a new range of designs, but also in the evolution of new refrigerants: before the developments to which I have referred, refrigerants were gases already in use for other purposes, and not originally produced for refrigeration. We now have a range of gases specially produced for refrigeration.

The advent of the domestic refrigerator has opened up an extensive new field of refrigeration, differing in many aspects from commercial refrigeration. Still further developments are likely in this field. Valuable as these developments are, the chief importance of the refrigerating industry to this country will always lie in the possibilities it gives for the safe transportation and storage of the immense quantities of imported perishable foodstuffs on which the life of the people depends.

* Delivered at a meeting of the Institution held in London, on October 24, 1947. Abridged.

WORM-GEAR TESTING MACHINE.

The David Brown Tool Company, Huddersfield, have recently introduced a machine known as the David Brown universal worm-gear testing machine No. 12A, a photograph of which is reproduced in Fig. 1, on this page. It is designed to check all dimensions on which the performance and interchangeability of a worm depend, and to test a worm wheel by observing the tooth-to-tooth contact when it is meshed with a master worm. It also provides a convenient mounting for meshing worms and wheels when the quantity to be produced does not justify the provision of a master worm.

The bed of the machine embodies two longitudinal slideways and one transverse slideway, which are shown in Fig. 2. The main longitudinal slideway supports two headstocks, and the worm to be tested is mounted between the centres. It will be seen from Figs. 1 and 2 that one of the headstocks is provided with a dividing-head, the use of which will be described later. Both headstocks may be clamped to the bed in any position to suit the length of the worm shaft. The secondary longitudinal slideway supports either of two testing accessories which are provided, and these may be mounted or removed without disturbing the headstocks. The transverse slideway carries a worm-wheel arbor on a saddle, which may be traversed, to bring the wheel in or out of mesh with the worm, by turning either of the two handwheels which are provided, one at each end of the traversing screw. Each handwheel has a graduated ring and vernier which enable the arbor to be set transversely to within 0·001 in. or 0·01 mm. Vertical adjustment of the worm wheel on the arbor, of about 1 in., is provided by a handwheel, the internal threads of which raise or lower a screwed sleeve, which bears on the worm wheel and is prevented from rotating by a key. By means of graduations on the circumference of the handwheel, the vertical setting of the worm wheel may be adjusted to within 0·001 in. or 0·01 mm. The bed of the machine is supported at three points, and is bolted to a welded-steel cabinet which accommodates the accessories, etc.

The worm to be tested is mounted between the centres, and checked first for concentricity by means of a dial gauge which is graduated to 0·001 in. or 0·01 mm., as required. The gauge is fixed to ball-mounted carriages at right angles to each other, which are supported on the secondary slideway by a saddle and a top-slide which may be traversed to suit the diameter of the worm. The saddle may be moved longitudinally along the slideway and locked in position. A spring plunger connected to the gauge is in contact with the worm, and the latter is rotated by hand to test for concentricity.

The axial-pressure angle or the base-lead angle, the indexing, and thickness of the worm threads are checked by three tests (definitions of these and other worm-gear terms are given in British Standard Specification No. 721 (1937), Part C, Worm Gearing). The same type of test is used for checking both the axial-pressure angle and the base lead angle of the worm, and the arrangement of the machine and accessory for this purpose is shown in Fig. 2. The accessory consists of a saddle (clamped to the slideway), which is provided with a swivelling top-slide carrying a dial gauge. One end of a pivoted stylus touches the flank of the thread, and the other end actuates the dial gauge. The stylus may be adjusted vertically for checking the pressure angle on any horizontal plane from zero to 3-in. base radius.

The swivelling top-slide is set approximately to the required axial-pressure or base-lead angle by means of a graduated scale; and it is finally adjusted by checking the distance between two sine studs, with a micrometer set to a value which is obtained from a formula engraved on the base of the accessory. The stylus may be set in the same horizontal plane as the axis of the worm, by using a height gauge or Johanssen blocks, which measure to a flat underside on the stylus; and the additional height to the top of the base circle may be obtained by using the vertical adjustment of the stylus. (The latter adjustment is required for checking the base-lead angle or tangential-pressure angle of an involute helicoidal worm, which has a thread flank which is straight sided on a line tangential to the base cylinder of the worm). The angle of the top-slide and the height of the stylus having been adjusted correctly, the stylus is passed along the flank of the thread by turning the handle of the top-slide, and any deviation from the correct angle is indicated by a movement of the needle of the dial gauge, which is graduated to 0·0001 in. or 0·002 mm.

The sine-bar pressure-angle accessory is also used for checking the indexing of the worm threads. The worm shaft is connected to the dividing-head plate by a suitable driver, the stylus is adjusted to touch the flank of a thread, and the dial gauge is set to zero. The indexing of the other threads is then tested by engaging the plate catch in the appropriate positions.

WORM-GEAR TESTING MACHINE.

THE DAVID BROWN TOOL COMPANY, HUDDERSFIELD.

Fig. 1.

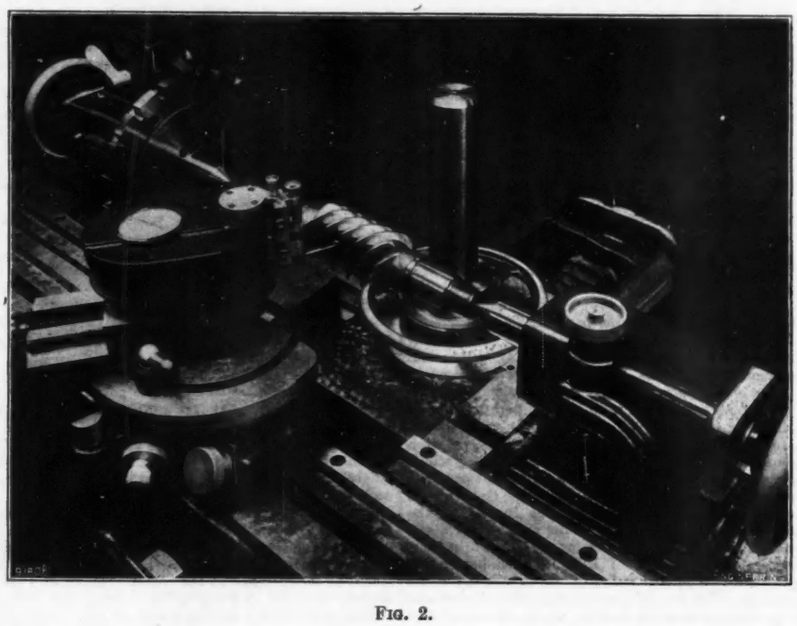
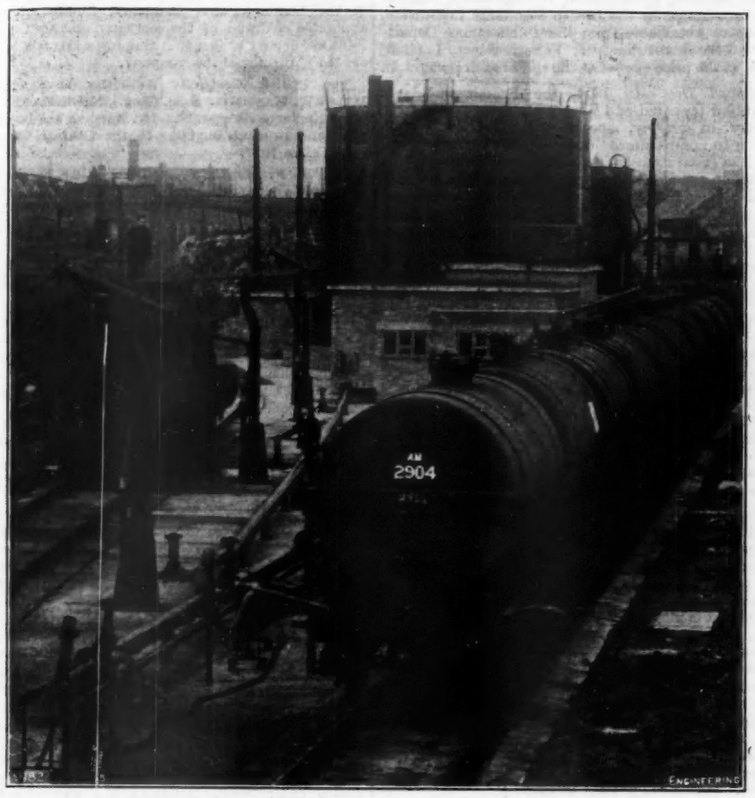


Fig. 2.

The final test of the worm is a comparative test using a master worm, and, in conjunction with the indexing and pressure-angle tests, it is a check on the thickness of the thread. The dial gauge is provided with a steel ball of a suitable diameter, which is inserted between the flanks of two adjacent threads of the master worm, and the gauge is set to zero. The master worm is then replaced by the worm to be tested, the ball is inserted between each pair of threads, and any error in thread thickness is shown as a plus or minus reading on the dial gauge. With a worm of normal design, any slight error in thickness is multiplied on the gauge, owing to the inclination of the flank of the thread. The dial-gauge mounting may be moved along the bed to other positions for further checks of the thread thicknesses. The latter may, of course, be checked with gear-tooth calipers; and it is necessary to do this when the number of worms to be manufactured does not justify the provision of a master worm.

FUELLING DEPOT FOR OIL-FIRED LOCOMOTIVES.



A special micrometer is used independently of the machine, for checking the thickness of the worm-wheel teeth. It consists of a straight-edge supporting an anvil arm and a micrometer-head arm. The arms slide on the straight-edge, and are clamped in positions to suit the diameter of the worm wheel. The anvil and the micrometer head are each provided with a ball, which fit in the grooves between diametrically-opposite pairs of teeth. The micrometer arm is in two parts, hinged together to allow the instrument to be applied to, and removed from, the worm wheel. The worm-wheel teeth are checked with this instrument by comparison with those of a master wheel.

The worm wheel is also checked by meshing it with a master worm. The latter is mounted between centres, and the worm wheel is fitted to the arbor with a suitable adaptor. The correct height of the wheel in relation to the worm is obtained by a special instrument. It consists of a straight-edge, one surface of which is placed across the top surface of the adaptor (before the wheel is fitted), and one end of the straight-edge is provided with a micrometer head which is adjusted, in accordance with the thickness of the worm-wheel boss, to touch a bar of known diameter mounted between the headstocks. Any error in the vertical position of the adaptor is corrected by turning the arbor handwheel. With the wheel to be tested and the master worm in position, the distance between centre lines is adjusted by one of the cross-slide handwheels; red-lead or Prussian blue is applied to the worm threads, and upon rotating the gears by hand the contacting areas on the worm-wheel teeth are revealed.

The principal dimensions of the machine are: maximum distance between centre lines of arbor and headstocks, 12 in. (300 mm.); maximum diameter of worm, 6 in. (150 mm.); maximum length of worm shaft, 2 ft. 6 in. (760 mm.); and floor space occupied by the machine, 4 ft. by 3 ft. (1·2 m. by 0·9 m.).

JAMES CLAYTON LECTURE.—The fourth James Clayton Lecture of the Institution of Mechanical Engineers, will be delivered at the Institution, Storey's-gate, St. James's Park, London, S.W.1, on Friday, December 19, at 5.30 p.m. The lecturer, Major-General Sir E. Bertram Rowcroft, has chosen as his subject, "Problems Encountered by R.E.M.E. in the Field." It is hoped that the lecture will be repeated at some of the Institution's local branches at dates and places to be arranged later.

FUELLING DEPOT FOR OIL-FIRED LOCOMOTIVES.

THE Great Western Railway Company have completed the construction of nine re-fuelling depots for the recently-converted oil-fired locomotives. They are situated at Old Oak Common, London; Reading; Didcot; Swindon; Newton Abbot; Severn Tunnel Junction; Newport (Monmouthshire); Cardiff; and Llanelly. Seven additional depots are in an advanced stage of construction. It is proposed to convert 172 locomotives to oil-firing, and 37 have been completed.

The depot at Old Oak Common, which was recently brought into use and is the largest on the company's system, is shown in the photograph reproduced on this page. The pump house is situated in the centre, adjacent to the storage tanks; the tank cars are in a siding on the right-hand side of the illustration; and three fuelling stand-pipes for locomotives will be noted on the left. The two welded tanks, each 30 ft. 2 in. in height and 34 ft. in diameter, will have a total storage capacity of 352,000 gallons. The site of one of the tanks is occupied, at present, by an American bolted tank of 175,000 gallons capacity, but this will be removed before the second permanent welded tank is erected. Ten discharging-pipe connections for tank cars are provided, and all the pipes for discharging and re-fuelling, both inside and outside the pump house, are heated by steam pipes which are lagged together with the oil pipes. Provision is also made for a supply of steam, through flexible connections, to the tank cars for heating the oil before it is pumped into the storage tanks. The re-fuelling stand pipes have been designed to obviate flexible gland joints, and it will be seen from the illustration that this has been achieved by using a flexible pipe which is controlled by a balanced arm pivoted at the top of the stand. When the arm is swung round so that the oil-delivery pipe is directed into the tender-filling hole, an electric light is automatically switched on to illuminate the level of the oil in the tender.

The pump house contains two double-acting duplex steam-driven oil pumps, each 8-in. and 6½-in. bore and 10-in. stroke, and with a capacity of 10,000 gallons of oil an hour. The pipes and valves of the depot are arranged so that each pump can be used either for discharging oil from the cars into the storage tanks or for delivering oil from the tanks to the locomotives. Two stationary locomotive-type boilers provide steam for the pumps and for heating the oil.

STRESS-CORROSION CRACKING OF STEELS.*

By W. P. REES, M.Sc.

STRESS-CORROSION cracking of metals may be defined as failure without plastic deformation, occurring as the result of the combined effect of stress, either external or internal, corrosive conditions, and time. The object of this work is to direct attention to certain cases of stress-corrosion cracking of steels exposed to media in which sulphur compounds have supplied the necessary corrosive conditions for such cracking to occur. The first case concerned the fracture of 0·020 in. diameter 18 per cent. chromium, 8 per cent. nickel steel wire used in a filter in a pipe-line carrying crude petroleum. The wire was in the hard-drawn condition and required a load of about 80 lb. to break it. In the filter the wire was wound round formers under a tension of 30 lb. Fracture of the wire occurred after as short a time as 90 hours, and the failures were all of the same type, the fractures consisting of a transverse part extending approximately half-way through the section of the wire and a longitudinal part which tended to split the wire in half. This form of fracture suggested the presence of high internal stresses. No visible corrosion had occurred, the surface of the wires remaining perfectly bright.

In view of the very short time in which fracture sometimes occurred, it was thought that fatigue had not been responsible for the failures, although the wire filter was subjected to fluctuating oil pressure from the pumps. Since it was known that the oil might contain several per cent. of hydrogen sulphide, tests were made in the laboratory on unbroken wires to determine their behaviour when stressed in an atmosphere of this gas. Lengths of wire passing down a glass tube were loaded by suspending 30-lb. weights at their ends and then hydrogen-sulphide gas was passed through the tube. The gas, generated in a Kipp's apparatus, was first bubbled through water to remove acid spray and to saturate it with water vapour. Some of the wires were coated with vaseline before the test. With a weight of 30 lb. suspended from the wires (stressing the wires to approximately 40 per cent. of their breaking strength), fracture occurred in from 2 hours to 7 hours if the hydrogen sulphide were saturated with water vapour. The presence of vaseline on the wire had, if anything, an accelerating effect on failure.

If the hydrogen sulphide were dried with calcium chloride before passing over the loaded wire, failure did not occur over a period of 80 hours. It was found that cold-drawn high-carbon steel wire was susceptible to failure when loaded to 40 per cent. of its breaking load and similarly exposed to moist hydrogen sulphide, while nickel and brass wire remained unbroken after 600 hours under the same conditions. The behaviour of the cold-drawn 18:8 steel wire in the pipe-line, and the results of the laboratory test, showed that this material would fail by stress-corrosion cracking in the presence of moist hydrogen sulphide.

A case of cracking of the flapper-valve plates of an air compressor was accompanied by features which indicated that some factor other than the repeated impact stresses to which the plates were subjected during service had contributed to the failure. The cracks were branching, and filled with a corrosion product, although there was no general corrosion on the valve surfaces. In view of the known behaviour of the steel wires, it was decided to expose a small specimen, stressed to below the yield point by bending in a jig, to an atmosphere containing hydrogen sulphide. This was done by placing the stressed test-piece in a closed glass vessel, in the bottom of which there was an aqueous solution of hydrogen sulphide. The test-piece broke in less than two days. The material, in this case stainless steel of the 12-14 per cent. chromium type, was used in the quenched and tempered condition with a diamond-pyramid hardness of 400-450.

During the period when light-weight alloy-steel cylinders for storing either coal gas or hydrogen were being developed, some cylinders burst under conditions in which the cylinders could not have been subjected to stresses greater than the maximum design working stress of 25 tons per square inch. Previous experience of the behaviour of steel exposed to hydrogen sulphide, and the fact that the ordinary heat-treatment oxide scale on the inside surfaces of some of the burst cylinders was found to contain approximately 2 per cent. of sulphur as sulphide, indicated that the cylinders may have failed by stress-corrosion cracking under the combined influence of the high working stress and the sulphur-containing impurities known to be present in the gases charged into the cylinders. Tests to investigate the behaviour of steels used for these light-weight

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* Paper entitled "Note on Stress-Corrosion Cracking of Steels in the Presence of Sulphur Compounds," presented at the Symposium on Internal Stresses in Metals and Alloys, organised by the Institute of Metals and held in London on October 15 and 16, 1947. Abridged.

cylinders, namely, nickel-chromium-molybdenum and manganese-molybdenum steels in the hardened and tempered condition (65 tons to 70 tons per square inch tensile strength), have shown that, when subjected to the combined action of stress and attack by sulphur-containing compounds, both steels are subject to stress-corrosion cracking. Hydrogen sulphide and carbon disulphide will both produce the effect, and, as in the first case quoted, the presence of moisture appears to be necessary. The tests, which are described in detail in a paper recently presented to the International Congress of Pure and Applied Chemistry, 1947, have shown that stress-corrosion cracking will occur in these steels at stresses as low as 10 tons per square inch, and consequently below the working stress of the cylinders.

The work on which this note is based has been carried out as part of the Research Programme of the National Physical Laboratory, and this note is published by permission of the Director of the Laboratory.

LAUNCHES AND TRIAL TRIPS.

S.S. "CORTONA."—Single-screw refrigerated-cargo vessel, built and engined by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn-on-Tyne, to the order of the Donaldson Line, Limited, Glasgow. Main dimensions: 425 ft. by 62 ft. 6 in. by 38 ft. 10 in. to shelter deck. Double-reduction geared turbine set to develop 6,800 shaft horse-power in normal service. Trial trip, October 27.

M.S. "PENLEE."—Pilot vessel, built by Messrs. A. and J. Inglis, Limited, Glasgow, for the Corporation of Trinity House, London. Gross tonnage, 420. Launch, October 30.

M.S. "SHERBRO."—Single-screw cargo vessel, built by the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, for Messrs. Elder Dempster Lines, Limited, Liverpool. Main dimensions: 385 ft. by 57 ft. by 32 ft. 9 in. to shelter deck; deadweight capacity, 6,211 tons on a draught of 22 ft. 4 in. Doxford four-cylinder opposed-piston oil engine of 3,100 brake horse-power, built and installed by Messrs. Richardsons, Westgarth and Company, Limited, Hartlepool. Trial trip, October 31.

M.S. "MERCIAN."—Twin-screw cargo vessel, built and engined by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Wallsend-on-Tyne, for Messrs. Ellerman Lines, Limited, London. Main dimensions: 255 ft. by 42 ft. by 25 ft. to shelter deck; deadweight capacity, 1,750 tons on a draught of 17 ft. Two sets of Polar six-cylinder two-cycle single-acting marine Diesel engines of 1,920 aggregate brake horse-power, to give a service speed of 12½ knots. Launch, November 11.

M.S. "CITY OF JOHANNESBURG."—Twin-screw cargo vessel, built and engined by Messrs. Barclay, Curle and Company, Limited, Whiteinch, Glasgow, for Messrs. Ellerman Lines, Limited, London. Main dimensions: 497 ft. by 64 ft. by 36 ft. 6 in. to upper deck; deadweight capacity, 10,500 tons on a draught of 29 ft. 10 in. Two Barclay, Curle-Doxford four-cylinder opposed-piston oil engines of 9,000 aggregate brake horse-power. Trial trip, November 13.

S.S. "VINDEGGEN."—Single-screw cargo vessel, built by Messrs. William Gray and Company, Limited, West Hartlepool, for Messrs. Rederiet Vindeggen A/S., Oslo. Main dimensions: 336 ft. overall by 47 ft. by 27 ft. 10 in. to shelter deck; deadweight capacity, 3,500 tons on a draught of 19 ft. Triple-expansion engine of 1,900 indicated horse-power, with two oil-fired boilers, supplied and installed by Messrs. George Clark (1938), Limited, Southwick Engine Works, Sunderland, to give a service speed of 12 knots. Trial trip, November 14.

M.S. "INTERPRETER."—Single-screw cargo vessel built and engined by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, for Messrs. Thos. and Jas. Harrison, Liverpool. Main dimensions: 460 ft. 3 in. by 60 ft. by 32 ft. 3 in.; deadweight capacity, about 9,270 tons. Doxford five-cylinder opposed-piston oil engine, to give a service speed of 14 knots. Launch, November 14.

S.S. "REDON."—Single-screw cargo vessel, built by Messrs. John Readhead and Sons, Limited, West Docks, South Shields, to the order of the French Government. Deadweight capacity, about 7,500 tons on a draught of 23 ft. One set of Parsons geared turbines, to develop a service power of about 3,300 shaft horse-power, constructed by the Parsons Marine Steam Turbine Company, Limited, Wallsend-on-Tyne. Launch, November 14.

MANCHESTER STATISTICAL SOCIETY.—The meeting of the Industrial Group of the Manchester Statistical Society, at which a paper by Mr. J. Morley on "Some Statistical Experiments in the Steel Industry" is to be read, will now be held on Friday, December 5, at 6.45 p.m., at the Society of Architects, 16, St. Mary's Parsonage, Deansgate, Manchester. This meeting had been arranged previously for November 28.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Diamond Dies.—In 1944, the British Standards Institution prepared and issued, at the request of the Ministry of Supply, specification B.S. No. 1168, relating to non-reinforced diamond dies for wire-drawing. The Institution have now completed and issued a companion specification, B.S. No. 1393-1947, for reinforced diamond dies. The committee responsible for its preparation state that, while they have been conscious of the difficulties to be overcome in the preparation of such a specification, they nevertheless feel that the new standard, even if not fully adequate in certain respects, will furnish guidance to both manufacturers and users. The specification covers reinforced dies having bores up to 0·06 in. in diameter. It indicates the desirable characteristics of the diamond and defines the appropriate wall thicknesses and minimum weights for various bores. Provision is made for three grades of finish of the die hole; its dimensional accuracy is prescribed, and notes on methods of examining and measuring the bores are included. The essential dimensions of the steel, brass, or other suitable material die case, are specified, together with a marking system indicating the metal for which the die is suitable. [Price 2*s.* 6*d.*, postage included.]

Electric Cranes.—A revision of specification B.S. No. 466, covering electric overhead travelling cranes for general use in factories, workshops and warehouses, has recently been issued. The specification, which was first published in 1932, does not apply to special-purpose cranes, such as heavy-duty steelworks cranes, for which it is intended to prepare a separate standard. In the present specification, such fundamental principles as appear desirable to ensure reliability and safety are laid down, without imposing restrictions in regard to design or mode of construction. Several new clauses have been added to the revision, and the appendices dealing with the materials and equipment to be employed in the manufacture of the cranes have been extended. The list of statutory requirements affecting the use and working of the cranes has been brought up to date. [Price 4*s.*, postage included.]

BOOKS RECEIVED.

Spectrochemical Abstracts. Volume III. 1940-1945. By ERNEST H. S. VAN SOMEREN. Adam Hilger Limited, 98, St. Pancras-way, London, N.W.1. [Price 12*s.* 6*d.* net.]

Rebuilding Europe's Fat Supplies. The Problem and How to Meet It. Lever Brothers and Unilever Limited, Unilever House, Blackfriars, London, E.C.4. [Free.]

Hand Book of the Wellington Harbour Board. June, 1947. The Secretary and Treasurer, Wellington Harbour Board, Wellington, N.Z.

The Institute of Petroleum: Its Development and Functions. The Secretary, The Institute of Petroleum, Manson House, 26, Portland-place, London, W.1. [Free.]

Practical Workshop Mathematics Illustrated. By PROFESSOR C. A. FELKER. Revised edition by J. L. THOMSON. Odhams Press, Limited, Long-acre, London, W.C.2. [Price 9*s.* 6*d.*]

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 16. *Economic Comparisons Between the Various Types of Underground Locomotives.* By PROFESSOR DR.-ING. HEINRICH KOCH. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

Department of Scientific and Industrial Research. Building Research. Technical Paper No. 30. *The Application of Electro-Osmosis to Practical Problems in Foundations and Earthworks.* By L. CASAGRANDE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9*d.* net.]

The J. & P. Switchgear Book. Being an Outline of Modern Switchgear Practice for the Non-Specialist User. By R. T. LYTHALL. Fourth edition. Johnson and Phillips, Limited, Victoria Works, Charlton, London, S.E.7. [Price 25*s.* net.]

The Crabtree Electrical Handbook. Second edition. J. A. Crabtree and Company, Limited, Walsall. [Price 2*s.* 6*d.* net.]

Engineering Industries Association. The Finance Act, 1947. A Synopsis for Engineers Relating to the Income Tax Provisions and the Profits Tax. Appendix: Income Tax Annual Allowances (Wear and Tear). Offices of the Association, 9, Seymour-street, London, W.1. [Price 3*s.* 6*d.*]

PERSONAL.

IN consequence of the death of the EARL OF LYTTON, MAJOR HARRY RICHARDSON, M.C., J.P., deputy chairman of the London Power Company, Limited, has been appointed chairman of the company, and MR CLARENCE PARKER, deputy chairman. SIR JOHN DALTON has been elected a director of the company.

The British Electricity Authority have appointed MR. C. W. MARSHALL, B.Sc. (Eng.), M.I.E.E., as Deputy Chief Engineer (Research). Mr. Marshall has been technical and research engineer to the Central Electricity Board since 1927.

MR. B. N. MACLARTY, O.B.E., M.I.E.E., has been appointed a deputy engineer-in-chief of Marconi's Wireless Telegraph Company, Limited, Chelmsford.

MR. J. DEARDEN, M.Sc., A.M.I.Mech.E., has been appointed acting chief metallurgist, London Midland and Scottish Railway, in succession to DR. H. O'NEILL, M.Met., who, as announced on page 154, *ante*, has relinquished the position of chief metallurgist to take the Chair of Metallurgy in the University College of Swansea.

COMMANDER (E) F. W. HORNSBY, M.I.Mech.E., R.N. (ret.), hitherto on the staff of the Armament Design Department, has now joined the Ministry of Supply as Assistant Director, Standardisation (Defence), Shell-Mex House, Strand, London, W.C.2.

REAR-ADMIRAL L. D. THE MACKINTOSH OF MACKINTOSH, C.B., D.S.O., D.S.C., is to be Vice-Controller (Air), Chief of Naval Air Equipment and Chief Naval Representative at the Ministry of Supply. The appointment will take effect early in January, 1948.

MR. J. A. WILKS and MR. W. F. WRIGHT have retired from the Department of the Chief Mechanical Engineer (Railways), London Passenger Transport Board, 55, Broadway, London, S.W.1. Mr. Wilks held the appointment of assistant mechanical engineer (running) and Mr. Wright that of chief depot engineer.

MR. R. J. FOWLER, D.I.C., B.Sc. (Eng.), A.C.G.I., A.M.I.Struct.E., A.M.I.Mech.E., of 33, Woodthorne-road, Tettenhall, Wolverhampton, Staffordshire, has recently opened a consulting practice, specialising in the application of welding in engineering design and production.

Consequent upon the appointment of MR. J. H. BREBNER, O.B.E., as Chief Public Relations and Publicity Officer to the British Transport Commission, MR. G. DODSON-WELLS, M.B.E., has been appointed Acting Chief Public Relations and Publicity Officer, London Passenger Transport Board, 55, Broadway, London, S.W.1. Other new appointments to the British Transport Commission are that of MR. A. E. SEWELL as charges adviser, that of MR. S. B. TAYLOR as deputy secretary, that of MR. F. GILBERT as assistant secretary, Staff and Establishment Section, and that of MR. M. R. BONAVIA as assistant secretary, Development and Works Section.

MR. ASHLEY S. WARD, chairman of Thos. W. Ward, Limited, Albion Works, Sheffield, has relinquished the chairmanship of Lowmoor Best Yorkshire Iron, Limited, and MR. GEORGE WOOD, deputy chairman of Thos. W. Ward, Limited, has been appointed in his place. MR. C. L. FRY and MR. W. W. HICKMAN have been elected directors of the Lowmoor company, of which MR. FRY and MR. R. STUBBS are to be joint managing directors. MR. G. F. HANSON has been made works manager.

MR. R. A. DAVIS, C.B.E., has resigned his position as director of sales with Vauxhall Motors, Limited, Luton, Bedfordshire, the resignation taking effect on December 31. MR. C. H. FISHER, at present director of service and parts, will succeed to Mr. Davis and will combine these two directorates.

MR. PERCY W. DUNN has been elected chairman of the Junior Institution of Engineers, 39, Victoria-street, London, S.W.1, and MR. G. W. TOOKEY, A.C.G.I., and MR. S. J. CRISPIN, L.R.I.B.A., M.I.Struct.E., have been elected vice-chairmen. MR. W. N. S. BEVAN has been elected honorary editor, and MR. S. H. HOLE, M.I.Mech.E., has been re-elected honorary treasurer, and MR. J. A. ROBERTS honorary librarian.

MR. G. WESTON, B.Sc., A.M.I.E.E., who has been with the British Standards Institution, 28, Victoria-street, London, S.W.1, for over 20 years, and who has had a wide experience in a large number of sections of the work of the Institution, covering all branches of industry, has been appointed an assistant technical director of the Institution.

MR. S. G. SAUNDERS has agreed to act with MR. D. G. LEWIS as representative of the Institution of Heating and Ventilating Engineers, 71-74, Victoria-street, London, S.W.1, on the British Standards Institution Sub-Committee on Graphical Symbols for Heating and Ventilating Plant.

THE FAIREY AVIATION COMPANY, LIMITED, Hayes, Middlesex, announce that their final-assembly shops, production flight-testing section and experimental flight have now completed their move from Heston Aerodrome to White Waltham Aerodrome, near Maidenhead. (Telephone: Littlewick Green 251.)

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Outputs of steel last week suffered to some extent from the occurrence of routine lining problems at some of the melting furnaces. These threw certain units out of production for the time being. Even so, the weekly output was above 36,000 tons of ingots and castings, and deliveries to users were maintained at a very satisfactory level. Priority allocations were maintained at a high level, while shipbuilders and engineers received as much steel as they required. Thin plates remained scarce, and re-rollers again found supplies of billets and sheet bars rather below their requirements. There are prospects of obtaining more semies from Germany, and the Harriman report has stressed the desirability of making more use of German capacity for this purpose. Before the war, Scotland imported many thousands of tons of Continental semies annually, and this loss has made the burden on Scottish capacity almost unbearable. Scrap is still in very short supply, and most makers have barely one week's reserve in hand. Pig-iron production is still affected by the difficulty in procuring coke to operate the furnace capacity now available. It is feared that the new blast-furnace at Clyde Iron Works will not make a start until the end of the year.

Scottish Coal.—The improvement in stocks arising from better outputs and a prolonged spell of mild weather (for the time of year) is the main feature of the market. The winter now beginning is being faced with more coal than for a long time—there being on an average nearly 50 per cent. more coal in reserve than at this time a year go. The output of the week before last, for which figures are available, showed an increase to over 490,000 tons from the deep mines alone. This was the best week for nearly 4½ years, and may be attributed solely to the efforts of the men. The extra Saturday shift has helped the position to a great extent, though even more coal from this shift may be expected. Observers are now considering the possibility of resuming export trade on a larger scale, but it is fairly certain that no appreciable increase in exports will be undertaken until the winter needs of Scotland have been further considered. One of the chief dangers this winter is a possible breakdown in the supply of wagons and transport when weather conditions become severe, and to forestall such an eventuality the Board have made arrangements to enlist the co-operation of road transport to take as much coal as possible from the pits by road. The scheme is moving rapidly to completion, and it would appear that the transport danger has been tackled in good time this year.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The improving supply position on the Welsh steam-coal market last week resulted not only in some inland consumers receiving additional allocations, but also in some coal being spared for shipment abroad. Orders were received, the first since the fuel crisis last winter brought exports to an end, for British overseas bunkering depots. It was felt that the decision to release Welsh coal for this business was an indication that general exports were a stage nearer. Figures available for the first Saturday-morning shift operated under the recent agreement showed that an extra 48,648 tons of coal were being raised in the South Western Division. Of this quantity, about 40,000 tons came from South Wales collieries, where 161 pits worked with an average attendance of 71·7 per cent. Following the recent upward trend of production, the Division, in the week ended November 7, exceeded its target figure of 542,917 tons for the first time since the five-day week was introduced. The amount of coal raised was 543,700 tons. The Saturday shift increases the figure to 592,400 tons, which is the highest since December 18, 1943. Although the supply position has become far less acute, operators had no difficulty in finding a ready outlet in the home market for any extra coal available. Several important consumers have received larger allocations. The demand in this section has been very active and orders already in hand from the high-priority users were sufficient to earmark almost the whole of potential outputs for some months ahead. As a result, there was still no coal to spare for ordinary exports, and the only shipments being made, apart from the orders for bunker descriptions mentioned above, were those for special customers in Eire and Canada. Cokes and patent fuel were in demand, but supplies were well sold forward.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, business in tin-plate was active. The demand was good and the volume of business transacted was fairly satisfactory. The production is gradually increasing, and, given more labour, makers could take fuller advantage of the demand. In the export market, the sales show an increase, but the quantity is still well below the average of a pre-war week. Steel sheets are unchanged and makers are heavily committed for months.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Pig iron is in greater demand for furnace charges now that iron and steel scrap is in short supply. The production of steel, especially high-carbon qualities, falls short of requirements. Many steel-consuming works are unable to work at full capacity because they are not receiving sufficient steel sheets and bars, and it is stated that if there were a full supply there would not be enough fuel with which to process the steel. Employment in Sheffield industry is very satisfactory; the number of men, women and juvenile employees is about 20,000, which is a larger number than in pre-war days. A continual hindrance to production is the operation of staggered hours; manufacturers state that if the drafting of the scheme had been left to them, they could have produced one which would not have restricted production. Pressure is being exerted on makers of railway materials to accelerate the rate of delivery; some improvement has been effected, as a little more steel has become available. Wagon shortage, however, hampers progress; some few firms have arranged to deal at week-ends with incoming traffic, so that wagons may be unloaded and released when the works nominally are closed for the shorter working week.

South Yorkshire Coal Trade.—There has been some delay in bringing into force the longer working week at the pits, but the chief hindrances have been removed. At some collieries more coal has been raised. Deliveries have been fairly well maintained in spite of some foggy periods and a shortage of wagons. Washed and graded steams continue in strong request. Satisfactory deliveries of deep-mined coal have been made to electric power stations in addition to coal from opencast sites, which have been producing actively, aided by the fine weather. Coking coal allocations have been maintained and coke-ovens have been operating at full heats to meet the growing demands of the heavy industries; coke-oven gas is more plentiful. House coal, however, continues to be in short supply.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—While anxiety concerning the near future of the North-Eastern iron and allied trades has not been entirely removed, recent events have eased the situation and encouraged the hope that the threatened grave winter difficulties may be overcome. The aggregate tonnage output of iron and steel has reached a very high level, but to ensure the maintenance of the huge make the continuation of the recently improved fuel deliveries is essential. Firms turning out pig-iron, foundry material and steelworks products are still unable to cope with their customers' urgent requirements. Arrears of delivery are heavy and the tonnage accumulations at the works are still inconveniently large though the rather better supply of wagons has enabled some of the material awaiting distribution to be cleared. The yield of local ironstone is still disappointing and supplies of iron and steel scrap are much below requirements. The import of high-grade foreign iron ore continues at a satisfactory level. The demand for semi-finished and finished iron and steel is considerably greater than the producers can supply.

Foundry and Basic Iron.—The shortage of ordinary foundry pig and of heavy cast-iron scrap continues gravely to hamper operations at plants turning out light castings, larger supplies of which are urgently needed. Substantial parcels of basic iron are being used at the makers' own consuming departments, but larger quantities could be absorbed.

Hematite, Low-Phosphorus and Refined Iron.—There is no actual shortage of East-Coast hematite, but users are quickly taking up full allocations and larger deliveries for stock would be welcome. The available tonnages of low- and medium-phosphorus grades of iron are still below current requirements, and there seems little likelihood of an early increase in supplies.

Manufactured Iron and Steel.—Semi-finished and finished iron manufacturers have extensive bookings and are being heavily pressed for larger supplies. Steel producers have much greater commitments than they can meet. The shortage of some descriptions of steel semies is rather less acute than of late, but billets, blooms and sheet bars are still wanted in larger quantities than are obtainable. Ingot production, however, is keeping pace with the requirements of the heavy rolling mills. Finished steel continues in great demand, the materials most needed being black and galvanised sheets, colliery equipment, railway requirements of all types and shipbuilding material.

Scrap.—As a considerable tonnage of German shipping is to be brought over here shortly for breaking up, deliveries of scrap metal of many varieties are likely to be on an improved scale,

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, November 24, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Industrial Applications of Inductor Alternators," opened by Dr. J. H. Walker. *North-Eastern Centre:* Monday, November 24, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. Report on "Practical Training of Professional Electrical Engineers." *South Midland Radio Group:* Monday, November 24, 7 p.m., James Watt Memorial Institute, Birmingham. "B.B.C. Engineering Division in War Time," by Mr. H. Bishop. *Scottish Centre:* Tuesday, November 25, 6.30 p.m., Royal Technical College, Glasgow. "Ultra-High-Speed Relays for Measurement and Protection," by Mr. W. Casson and Dr. F. H. Last. *London Students' Section:* Wednesday, November 26, 7 p.m., Victoria-embankment, W.C.2. "Impulsing: the Heart of Automatic Telephony," by Mr. R. F. Howard.

ROYAL STATISTICAL SOCIETY.—*Industrial Applications Section:* Monday, November 24, 6.30 p.m., University, St. George's-square, Sheffield. "Examinations Examined," by Mr. F. C. Turner.

INSTITUTION OF MECHANICAL ENGINEERS.—*Yorkshire Branch:* Monday, November 24, 7 p.m., Royal Victoria Station Hotel, Sheffield. Thomas Hawksley Lecture, by Sir Alwyn D. Crow. Also at *Western Branch:* Thursday, November 27, 5.45 p.m., Royal Naval Engineering College, Plymouth. *Southern Branch:* Thursday, November 27, 6.30 p.m., Municipal College, Portsmouth. "Feed Distribution and Hunting in Marine Water-Tube Boilers," by Mr. H. Hillier. AUTOMOBILE DIVISION. *Birmingham Centre:* Tuesday, November 25, 6.30 p.m., James Watt Institute, Birmingham. "Cylinder-Head Design," by Mr. J. Swaine. *North-Western Centre:* Wednesday, November 26, 7.15 p.m., Walker Engineering Laboratories, University, Liverpool. "High-Speed Compression-Ignition Engines," by Messrs. S. Markland and N. Tattersall.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 25, 5.30 p.m., Great George-street, S.W.1. Meeting with SOCIÉTÉ DES INGÉNIEURS CIVILS DE FRANCE (BRITISH SECTION). "Latest Developments in Dams and Hydro-Electric Power Stations in France," by Mr. André Coyne. *Birmingham Association:* Thursday, November 27, 7 p.m., Loughborough College, Loughborough. "Welding in Bridge Construction," by Mr. R. G. Braithwaite. *Yorkshire Association:* Friday, November 28, 7 p.m., Royal Victoria Station Hotel, Sheffield. "The Open Frame Girder," by Mr. E. Lightfoot.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, November 25, 6 p.m., 2, Savoy-hill, W.C.2. "Recent Advances in Physiology of Vision," by Professor H. Hartridge.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Scottish Branch:* Tuesday, November 25, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Development of Refrigeration," by Mr. A. K. Allcock.

ROYAL MICROSCOPICAL SOCIETY.—Wednesday, November 26, 6 p.m., B.M.A. House, Tavistock-square, W.C.1. "Microscopy of Enamelled Wire," by Mr. J.V. H. Wredden.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Birmingham Branch:* Wednesday, November 26, 7.15 p.m., James Watt Institute, Birmingham. "Graphite Formation in Cast Iron," by Mr. H. Morrough.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, November 27, 2.30 p.m., Caxton Hall, Victoria-street, S.W.1. "Piston Temperature," by Mr. G. B. Fox.

INSTITUTE OF REFRIGERATION.—Thursday, November 27, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Electrical Thermometry and Gas Analysis," by Mr. R. W. Griffin. "Automatic Expansion Valves," by Mr. C. E. Stratton.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, November 27, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Meaford Power Station," by Mr. F. T. Bunclark. *Midland Branch:* Friday, November 28, 6 p.m., James Watt Institute, Birmingham. Discussion on "Problems in Structural Design."

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 28, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Diesel Engine Design and Scavenging Problems," by Mr. H. Pyk.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 28, 6.30 p.m., 39, Victoria-street, S.W.1. "Metal Spraying," by Mr. J. Barrington Stiles. *South Midland Group:* Friday, November 28, 7.30 p.m., Technical College, Luton. "Precision Time Keeping," by Mr. A. E. Bowyer Lowe.

ROYAL INSTITUTION.—Friday, November 28, 9 p.m., 21, Albemarle-street, W.1. "Tracks of Charged Particles in Photographic Emulsions," by Dr. C. F. Powell.

EMERGENCY WAR-DAMAGE REPAIR WORK AT CALAIS.

(*For Description, see Page* 481.)

FIG. 27. TRAIN-FERRY TERMINAL.

FIG. 28. TEMPORARY FENDERS AT QUAI GARE MARITIME.

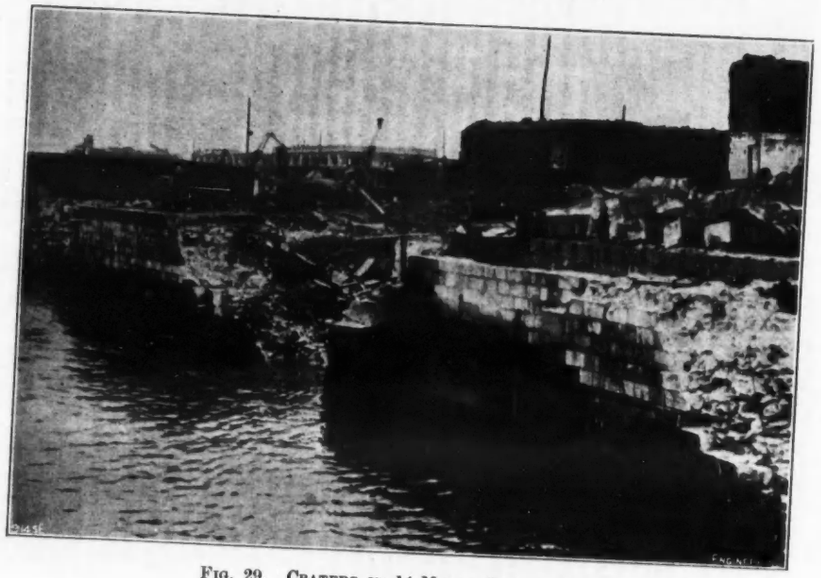

FIG. 29. CRATERS IN 14-METRE CARNOT LOCK.

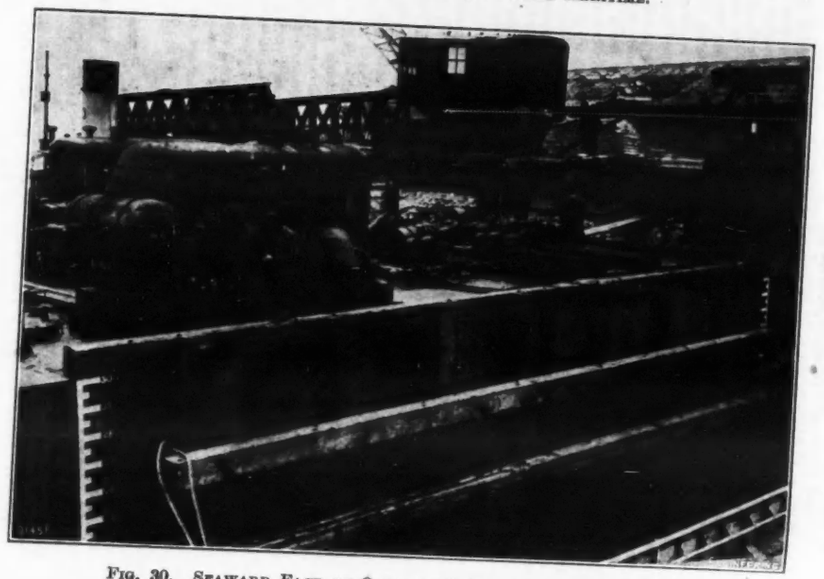

FIG. 30. SEAWARD FACE OF CAISSON, 21-METRE CARNOT LOCK.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, NOVEMBER 21, 1947.

VOL. 164. No. 4269.

RAILWAY BRAKE SHOES.

THE persistence of the homely term "shoe," in connection with the braking of vehicles, which, no doubt, goes back hundreds of years to the days when a wagoner would check the speed of his cart by pressing his foot on the rim of a wheel, is a tribute to the beautiful simplicity of a principle that has survived great advances in the effectiveness of the mechanism used for applying the braking force. In this feature, as in many others, railway practice has developed from that of horse-drawn traffic; and, despite the invention of many other types of brakes, one or two of which have been tried more or less experimentally on some of the recent American high-speed trains, the vast majority of railway vehicles in all countries are still braked by means of shoes or blocks pressed gainst the rims of the wheels.

For these and other reasons, the interest already vested in shoe brakes is so great as to make the improvement of that device more attractive than any sweeping change of principle. For much the same sort of reasons, improvements in brake-shoe materials have been few and somewhat hesitatingly adopted. Once the primitive wood shoes of the early railway brakes were superseded by cast iron blocks that could be readily replaced when they wore out, there has been little inducement to abandon a material which is remarkably cheap and, on the whole, effective. It was not until well into the present century that more stringent requirements in various aspects of railway operation suggested that, some day, the shortcomings of cast iron might present difficult problems. The preponderance of cast-iron shoes still in use to-day is evidence that those problems have not yet assumed really serious proportions.

Meanwhile, the non-metallic brake-lining materials, developed to a high state of perfection during many years of service in the automobile industry, have been adapted with a considerable measure of success for railway work, and promise remedies for many of the imperfections of cast iron. They consist, typically, of woven asbestos impregnated with a thermo-setting plastic resin, which can be moulded under heat and pressure to the same general shape and size as the conventional iron block, and are furnished with an integral metal backing to fit existing brake gear. The synthetic composition of non-metallic blocks, as the outcome of much experimental study, can be adjusted to give a range of frictional characteristics, and, in particular, to overcome a major detriment of cast iron by offering an effective coefficient of friction that is not only higher, but notably less dependent on rubbing speed and brake-block pressure. In contrast to the marked increase of braking effect with cast iron, as the retardation of a train progresses, the behaviour of non-metallic brakes is much preferable in its influence on passenger comfort and the tendency to cause wheel skidding at low speed. For electric trains, non-metallic blocks have the additional merit of not producing iron dust, which is a troublesome cause of short circuiting.

Up to the present, however, non-metallic shoes have not proved significantly superior to iron as regards the harmless dissipation of the heat generated by braking. Indeed, the facts, firstly, that an iron shoe is a good thermal conductor in contact with the brake rigging and exposed to cooling air, and hence contributes to absorb and dispose of heat; and, secondly, that, if the rubbing surface of a cast-iron shoe becomes hot enough to melt (which happens at a lower temperature than the melting point of tyre steel) its latent heat of fusion serves as a thermal reservoir, both tend towards a smaller total heat input to the wheel than when a non-conducting infusible composition shoe is used. Thermal cracking, surface shelling, metallurgical changes and other deleterious effects of over-heated wheel treads are not, however, the usual consequences of total heat input, but are rather due to excessive temperature rises that are local and temporary. In general, actual contact between the shoe and wheel occurs momentarily over only a few small areas which are necessarily subject to intensities of pressure much above the nominal average, with the result that narrow circumferential areas around the tread are heated to surface temperatures exceeding 800 deg. C. for a short time, until any particular "high spot" on the shoe is worn away and another contact area takes its place. Thus, during a prolonged brake application, transient overheating of the tread fluctuates across the width of the shoe, producing complex distortion and unnecessarily rapid deterioration of the tyre.

Obvious prerequisites for a first experimental study of these phenomena are a laboratory brake-testing machine in which wheel speed, brake-shoe force and energy absorption can all be controlled and measured; and a reliable and accurate device for determining transient temperatures. The former is a prominent item of equipment in the research laboratories of Messrs. Ferodo, Limited, at Chapel-en-le-Frith, and it is therefore appropriate that two of that company's physicists, Dr. R. C. Parker and Dr. P. R. Marshall, should have conducted an investigation which was the subject of a paper presented to the Institution of Mechanical Engineers on November 7. A trustworthy method of measuring the high temperatures generated locally between sliding surfaces has been needed for many years, for research into various fundamental and applied problems of unlubricated friction, and it is especially to the credit of Dr. Parker and Dr. Marshall that they have apparently developed into a successfu practical instrument a pyrometer of which the essential element is a lead-sulphide photo-conductive cell. Their apparatus records on a cathode-ray oscillograph, and is claimed to cover the temperature range from 200 deg. to 900 deg. C., with a response time of one thousandth of a second. Taking account of numerous sources of possible error, they experimented with brake blocks made, respectively, of cast iron and two types of non-metallic "Ferodo," applied to a spoked railway-carriage wheel of which the tyre tread was finished by surface grinding.

From their not unexpected results, demonstrating the bad effects of elevated temperatures at the treads consequent upon localised contact areas between the brake shoe and tyre, the authors reach the

important practical conclusion that a non-metallic shoe, on account of its plasticity, can make contact across its whole width if its length is reduced to something like half that of the standard shoes now in use. By this means, the heat generated in the tyre by a given dissipation of energy during a brake application is distributed across the tread, thereby avoiding high localised temperatures while decreasing the rate of shoe wear and giving greater uniformity in friction. More specifically, tests with half-length non-metallic blocks have shown that the tyre temperature does not rise as high as the melting-point of the tyre steel, and that the braking friction does not "fade," when the tyre is hot or wet, to the same extent as occurs with a full-length shoe.

In the course of the discussion of this paper, more than one speaker referred to the improvement in braking characteristics which is well known to ensue in the case of cast-iron when two, or sometimes four, shoes are substituted for a single one of greater length. It may be, therefore, that further improvement is worth seeking by subdivision of a short non-metallic block. Any feasible means of minimising metallurgical changes caused by the heating of the tyre is certainly worth pursuing, since non-metallic shoes are alleged to polish the tyre treads, with detriment to the adhesion of driving wheels on the rails, but without abrading the shallow surface layer containing thermal cracks. Cast iron, on the other hand, is reputed to wear away shallow cracks almost as fast as they are formed and to wear itself fairly quickly to the profile of the tyre, doing something in the process to restore the true conical form of the tread.

This difficulty did not arise with the accurately profiled wheel on which the Ferodo Company's laboratory tests were conducted, and may not prove serious in practice if the shoe wears rapidly to fit the wheel. Durability, however, is one of the desirable qualities that non-metallic brakes are designed to achieve, and rightly so, since the frequent replacement of worn shoes represents a substantial proportion of the total cost of brake maintenance. Alternatively, of course, the difficulty would be met by a shoe which, fitted new to a newly profiled wheel, would last until the wheel were worn enough to need reconditioning; but the prospect of a general solution along such lines is not hopeful, if only because the relation between the amount of braking and the mileage causing tread wear varies widely for different types of traffic. In practice, too, it will be important to take account of the extent to which the brake-shoe wears the tyre, from the standpoint both of the riding qualities of the worn tyre and of the amount of metal that has to be removed in order to restore the original profile.

Such points exemplify the highly complex economics of train braking, which was given some attention by the Ferodo Company's physicists, mainly with respect to the optimum lengths of non-metallic shoes of two different compositions. This is certainly important, and is of interest as offering scope for the synthesis of materials to meet different requirements; but it is by no means the only factor in which economics, physical properties and performance are intimately interconnected. The composition and metallurgical properties of the tyre steel, for instance, affect the wear of the rail and the tyre as well as the behaviour and deterioration of the tyre during brake applications. Again, the cost of brake-shoe renewal is influenced by differing braking conditions appropriate to underground, outdoor or suburban and high-speed trains, to multiple-unit electric and locomotive-drawn coaches, or to locomotives and vehicles, as well as by the first cost of shoes of different materials. Over-riding all such factors is the engineering demand for large maximum braking forces without skidding between the wheel and the rail. Here, manifestly, is a very big problem, part of which has been solved fairly satisfactorily for the cast-iron brake shoe by years of experience, aided by investigations like those of Captain Galton. The complete solution for the non-metallic shoe will also need practical experience and will take time, but will be achieved the sooner for methodical scientific research of the quality displayed in Parker and Marshall's paper.

NATIONAL PARKS AND WATER SUPPLY.

THE agitation, characteristic of the present time, which demands that the public services and amenities available in large towns shall be extended in scope to cover the whole country, rural and built-up areas alike, has concentrated much attention on the question of the provision of electricity services and has given but little attention to the matter of water supply. The convenience and value of an electricity service from public mains require no emphasis but, in cottage and mansion alike, pure water in adequate quantity is more important even than electric light or the possibility of operating a mains radio set. There have been recent indications that this matter is at last receiving more adequate public attention. The Water Act, 1945, providing for the setting up of a Central Advisory Water Committee, is evidence of a growing realisation of the fact that the water-supply problem should be studied from the point of view of the country as a whole, and the recent proposal for the administration of the London Basin, put forward by the Metropolitan Water Board, covers a specific scheme for the unification of supply arrangements over a large and important area. The necessity for introducing some order into the exploitation of the limited water supplies of the country was recognised by the late Mr. A. E. L. Chorlton, who put forward proposals for what he termed a "water grid." This suggestion was the subject of much misrepresentation, but its essential feature, which was a plea for the co-ordinated development and utilisation of water resources, was sound and to a considerable extent,, will ultimately form the basis of practice.

The importance of pure and abundant water supplies was the text of the presidential address which Sir Roger Hetherington delivered to the Institution of Civil Engineers on November 4, and to which a brief reference was made on page 447, *ante*. The effect of such supplies on public health was illustrated by reference to cholera, typhoid and typhus. The first and second of these were serious diseases in this country in the early years of the Nineteenth Century, but the first had practically disappeared by about 1870 and the latter had fallen to very small proportions by 1920. Sir Roger indicated that both of these were waterborne diseases, but in view of the present extensive employment of D.D.T. in Egypt, the opinion is evidently held that cholera may be disseminated also in other ways. Typhus is definitely louse-borne, but its eradication is dependent on cleanliness, which can only be secured by adequate and reliable water supplies. In 1869, the annual death rate from typhus was 193 per million persons living, but in 1898 the figure had fallen to one. It has now practically disappeared.

Improved housing, the advance in medical knowledge, and other factors, have influenced the improvement in public health, but Sir Roger's contention that it could not have been attained without the great development in public water supplies is not likely to be contested. The change that has come about in the last hundred years is illustrated by some figures given by a Royal Commission in 1844. In Nottingham, 70,000 houses had no regular or adequate supplies; in Bristol, only 5,000 out of 130,000 people had water laid on; in Birmingham, only 8,000 houses out of 40,000; and in Coventry, 300 to 400 out of 7,200. It is not only owing to the greater number of people served that water consumption has increased so enormously; the amount used per consumer has risen correspondingly. Sir Roger suggested that a century ago the consumption per head in the poorer districts did not exceed 2 or 3 gallons per day; it is now about 17 gallons. This figure is by no means a maximum; when some bombed-out families moved into flats at Earls Court during the war, their daily consumption was 37·9 gallons per head.

The increase in water-demand per individual, coupled with the increase in population, particularly in towns, has forced many large cities to tap water sources in remote districts, examples being furnished by Liverpool, Birmingham and Manchester. This procedure which appears admirable from every point of view, except that it is rather expensive, has raised a new problem in recent years. It is clearly desirable that gathering grounds should be kept free from pollution, but modern travelling facilities are making this every day more difficult and matters are likely to be made worse by the scheme for the creation of national parks, which will tend to encourage and facilitate a considerable influx of visitors to remote country areas. On broad lines the national-park project is commendable and will in itself tend to preserve selected rural districts from exploitation, either for industrial or residential purposes, but in the selection of the areas no attention appears to have been given to a possible deleterious effect in important water-supply areas.

Some information about the impact of the national park policy in a specific case was given in a paper entitled "National Parks and Watersheds" presented by Councillor John Stewart to the annual congress of the Royal Sanitary Association of Scotland last month. His concern was with the possible effect on the water supply of Glasgow, which is obtained from a catchment area of about 27,000 acres, situated around Loch Katrine and the Trossachs, some 35 miles north of the city. It is natural that this attractive district should have been chosen as one of the five Scottish national parks on the priority list, but that does not make it desirable that its relation to the water supply of Glasgow should be ignored. There are various roads through the area at present and there is limited access to various parts, but Mr. Stanley D. Canvin, general manager of the Glasgow Water Department, who spoke in the discussion following the reading of the paper, said that some visitors deliberately offend against existing regulations. As the scheme for the first five Scottish National Parks provides for the expenditure of 750,000*l.* for holiday accommodation and 500,000*l.* for houses and other buildings, the fears of the Glasgow water authorities that the purity of their supplies may be endangered appears entirely justified.

These authorities are in the fortunate position that they are able to supply 80 million gallons of water a day from Loch Katrine by gravitation and without filtration, and Mr. Canvin pointed out that if contamination were permitted the whole of this supply would have to be treated and pumped, which would raise serious financial and engineering problems. He did not deny that polluted water can be filtered and treated to make it suitable for general consumption, but suggested that "a water supply so filtered and chemically treated is a trend towards synthetic water." The Metropolitan Water Board which have to collect their supplies from areas very different from that in which Loch Katrine is situated, is hardly likely to describe the product it dispenses as "synthetic water," but that is no reason why sources at present unpolluted should be endangered without consideration of the issues involved.

The serious results which may follow from water pollution were pointed out by Councillor Stewart, who recalled that the Croydon typhoid epidemic resulted in 43 deaths and 341 cases of typhoid fever. An incident of that kind cannot but appear menacing to an authority supplying unfiltered water to over a million people. In the year 1919, the City of Glasgow purchased 25,000 acres of land within the watershed, at a cost of 77,000*l.*, purely for the purpose of controlling access and maintaining purity of the sources, and the possibility of being forced to throw open the area to the "irresponsibilities of picnic parties, touring parties, etc.," cannot be viewed without alarm. As already mentioned, there is already limited access to parts of the gathering ground by motorists and hikers, and a proportion of these are found to offend against regulations, but Mr. Canvin estimates that if the national-park project is carried through, hundreds will visit the area for every one or two at present.

Mr. Canvin suggested that before, and if, a National-Parks Bill is drawn up, there should be consultation between the appropriate Minister and the water authorities affected; that if the Minister's proposals are unacceptable, there should be a public inquiry; and that if water undertakings are unable to accept the findings of the inquiry, their areas should be omitted from the scheme and "included in an Order to be provisional only until confirmed later by Parliament."

NOTES.

NOBEL PRIZES.

ON November 13, the Swedish Academy of Science, Stockholm, announced that the award of the Nobel Prize in physics, for 1947, had been made to Sir Edward Appleton, G.B.E., K.C.B., D.Sc., F.R.S., for his researches on the ionosphere, and particularly for his discovery of the Appleton layer. It was also announced that the Nobel Prize in chemistry, for 1947, had been awarded to Sir Robert Robinson, D.Sc., F.R.I.C., F.R.S., for his researches concerning substances in plant biology, especially alkaloids. Sir Edward Appleton, who was elected a Fellow of the Royal Society in 1927, at the age of 35, and was awarded the Hughes Medal of the Society in 1933, was Wheatstone Professor of Experimental Physics, King's College, London, from 1924 to 1936, and Jacksonian Professor of Natural Philosophy at the University of Cambridge from 1936 until 1939. In 1939, he was appointed secretary of the Department of Scientific and Industrial Research and is still serving in this capacity. It was in the course of his work as an officer in the Royal Engineers (Signals) in the war of 1914-18 that Appleton became interested in the fading of wireless signals and was puzzled as to its explanation. This led him to wish to find out more about how wireless waves travel. As a result of experiments commenced in 1924, he was able to prove that short wavelengths of from 10 m. to 50 m. penetrated the Heaviside Layer but were reflected back to earth from a denser ionised region at a higher altitude. This was, in fact, the discovery of the "Appleton Layer," 120 miles above the ground. Further work on the ionosphere led to the development of radar. Sir Robert Robinson, winner of the Nobel Prize in chemistry, has occupied the chairs of organic chemistry of the Universities of Sydney (New South Wales), Liverpool, St. Andrews, Manchester and University College, London. He has been Waynflete Professor of Chemistry at Oxford University since 1930, and was elected President of the Royal Society in 1945. He has done much research work, mainly in organic chemistry and has made a special study of the chemical structure of the compounds found in plant life. He was awarded the Copley Medal of the Royal Society in 1942.

STANDARDISATION OF ELECTRICAL GENERATING PLANT.

A Statutory Rule and Order (No. 2,386 of 1947), dated Friday, November 7, 1947, confines the production of steam turbo-alternators of a capacity exceeding 10 MW to 30-MW and 60-MW sets. The steam conditions in the case of the 30-MW sets are to be 600 lb. per square inch and a temperature of 850 deg. F., the corresponding figures for the 60-MW sets being 900 lb. per square inch and 900 deg. F. Sets ordered prior to November 1, 1946, or produced under licence or for ships or export are, however, exempt. Explaining this Order at a Press Conference on Thursday, November 13, the Minister of Supply (the Rt. Hon. G. R. Strauss, M.P.) said that in planning the programme for plant to be commissioned from 1950 onwards, one of the most urgent problems was to cut down the time needed for the production of turbo-alternators by six to nine months; and the only way to do this effectively was to introduce standardisation. With this end in view, it had been decided, therefore, that only sets of the sizes mentioned should be manufactured, as no modern power station required units of less than 30 MW, while a 60-MW set was the largest in general demand and one for which manufacturers already had designs. At a later date, standardisation might also be introduced for boilers, pipe work and other components. It had further been agreed, he said, that when the Central Electricity Board directed an undertaking to provide generating capacity they would also lay down with whom the orders were to be placed, so as to ensure an even distribution among the appropriate factories. It was hoped to increase in 1948 the capacity of the generating plant installed by 1,000 MW, and that during succeeding years the operation of the Order would permit this annual increase to reach 1,500 MW without cutting down the export of heavy electrical equipment. This should be quite possible, as the potential capacity of the industry is believed to be about 3,000 MW. These figures compare with the 600 MW, which were installed annually in the years before the war. Although the effects of this arrangement will not be felt immediately, it is likely to be welcomed, especially by manufacturers, who in the past have frequently called attention to the economic disadvantages of the purchaser displaying undue individuality.

THE OLD CENTRALIANS.

The monthly luncheon that was held in London on November 14 by the Old Centralians—the association of former students of the Finsbury Technical College and the City and Guilds Engineering College—was the occasion of a ceremony which brought together the largest assembly that they have recorded since the war; namely, the presentation of his portrait in oils to Captain A. M. Holbein, F.C.G.I., who has been honorary secretary of the association for more years than were revealed at the luncheon. Mr. F. H. Bramwell, President of the Old Centralians, took the chair, and the presentation was made by Mr. W. H. G. Roach. Captain Holbein, in acknowledging the presentation of the portrait, which was executed by Mr. W. Woodington, a former student of the City and Guilds Art School, expressed his desire to present it to the College Union—where, we understand, it was hung, with appropriate ceremony, later in the day. The customary luncheon address was then delivered, also by Mr. Roach, who took as his subject "The Employers' Side of the Constructional Engineering Industries." After describing the functions of an employers' association and its connection with the British Employers' Confederation and the Federation of British Industries, he expressed the wish that more might be done to simplify and co-ordinate wage agreements; though he emphasised that, in the civil-engineering contracting industry, the relationship between employers and operatives was excellent.

ELECTRICITY SUPPLY IN SCOTLAND.

The Secretary of State for Scotland (the Rt. Hon. A. Woodburn, M.P.) has confirmed the North of Scotland Hydro-Electric Board's projects at Glen Lussa, Argyllshire (Constructional Scheme No. 8) and at Storr Lochs, Skye (Constructional Scheme No. 13). The first of these schemes includes a generating station in Glen Lussa to which water will be supplied through a pipeline from a reservoir on the Strathduie Water. This reservoir will be formed by the construction of a dam across a narrow gorge three-quarters of a mile from Gobagrenan. It is estimated that the output of electricity in an average year will be about 8,500,000 kWh. Provision is also made in the scheme for the erection of transmission lines on both sides of the Kintyre peninsula between Campbeltown and Tarbet. These lines will connect the new generating station with the existing Diesel station of the Campbeltown and Mid-Argyll Electricity Supply Company on the outskirts of Campbeltown, and also link up with the supply company's Tarbet-Ardrishaig system. Power will thus be made available for the Machrihanish colliery and for the further industrial development of Campbeltown. The Storrs Lochs scheme will utilise the waters of Loch Fada, Loch Leathan and tributary streams by the erection of a dam at the north end of Loch Leathan in the valley between Portree and Staffin, south of the precipice of Storr. From the reservoir thus formed water will be led to a generating station on the sea shore near the mouth of the Bearreraig River. This station will ultimately have an installed capacity of 2,400 kW with an average annual output of 5,500,000 kWh. Power will be distributed by the Board's distribution scheme for Skye, which was confirmed last year.

CONFERENCE FOR EXCHANGE OF STUDENTS.

Arrangements for the international exchange of technical students were initiated in 1946 by the organisers of the Vacation Work Scheme of the Imperial College of Science and Technology, London, in collaboration with the British Council and certain Continental and Scandinavian universities and technical colleges. The exchange provides students, during the summer vacation, with eight weeks' practical experience under industrial conditions in the country visited and gives them also an opportunity of living, as well as working, with the peoples of other nations. With the object of reviewing the progress made in 1947, when 220 students were exchanged between Great Britain and various European countries, a conference of the organisers of the scheme is to be held at the Imperial College, Prince Consort-road, London, S.W.7, from January 5 to 9, 1948. Another object of the conference is to formulate the standards of knowledge, training, and experience which are desirable for students taking part in the scheme. A third object is to obtain the co-operation of industry in the countries concerned, so as to facilitate the acquisition of practical experience on the part of the students and to enable them to earn emoluments sufficient to meet their living expenses. The fourth and final object of the conference is to arrange exchanges for 1948. Reports on the working of the scheme in 1947 are stated to be very encouraging and the promoters hope that industrial organisations will appreciate the mutual advantages to be gained as a result of a further development of the exchange arrangements during the summer of 1948. Representatives of Belgium, Czechoslovakia, Denmark, Finland, France, Holland, Norway, Sweden and Switzerland have accepted preliminary invitations to attend the conference, and, during the period of the meeting, the delegates will be the guests of the Imperial College Union. Further particulars may be obtained from the secretary of the Vacation Work Scheme of the Imperial College at the above address.

EARTHING CONSUMERS' ELECTRICAL INSTALLATIONS.

Difficulty is often experienced earthing consumers' electrical installations suitably and reliably in areas where there is no water supply or where that supply is given through non-metallic pipes. After consultation with a number of authorities, such as the Mines Department of the Ministry of Fuel and Power, particularly in relation to quarry installations, and the Post Office, the Electricity Commissioners suggest that undertakings might allow the consumers affected to connect their earth continuity conductor to the earthed neutral point of the supply system. This can be done either by direct connection, where the undertaking's transformer is on the consumer's premises, by an additional conductor, where the supply is by overhead line, or by a connection to the lead sheath of the cable, where it is underground. A connection might also be made to the nearest existing low-resistance and reliable earth. None of these courses appears to conflict with the Electricity Supply Regulations, 1937, and no specific consent or approval under these regulations is therefore involved. Prior approval, however, is essential where recourse has to be had to multiple earthing, either by connecting the undertaking's neutral to earth at more than one point or by connecting the consumer's earth continuity conductor to the neutral of the undertaking's overhead system. It is suggested that undertakings who are prepared to assist consumers by allowing the use of their systems in any of these ways should impose suitable safeguarding conditions by way of indemnity, to ensure that such use is at the risk of the consumer and that undertakings are relieved of responsibility for accidents either on the system or on the consumer's installation. The question whether undertakings should volunteer the use of their systems for earthing or whether they should wait to be approached by the consumer is left open, although the Commissioners feel sure that undertakings will desire to be of as much assistance as possible.

CENTENARY OF CASTON AND COMPANY.

The London firm of Caston and Company, Limited, of Tabard-street, London, S.E.1, who have been associated with the British lift industry since its inception, celebrated their centenary on Thursday, November 13, by a luncheon. The founder of the firm, George Caston, was a blacksmith who, in 1847, opened a shop in Great Dover-street, Southwark, for

the sale of wire lattice-work, and supplied wire screens to Richard Waygood for the first lifts manufactured in this country. When the Otis Elevator Company, of New York, established a branch in London, they did so as tenants of Caston and Company; and when, in due course, the business of Richard Waygood and Company was amalgamated with the Otis Elevator Company to form the present firm of Waygood-Otis, Limited, the Caston works continued in close association with both. George Caston died towards the close of the Nineteenth Century, and the business was made a limited company by Mr. C. J. Heffer (who was present at the centenary luncheon) and his cousin, the late Mr. H. C. Walker, afterwards chairman and managing director of Waygood-Otis, Limited, so that the connection with lift construction is well maintained. Subsequently, the firm acquired the Phœnix Art Metal Works, to extend their scope to include ornamental wrought-iron work; and, in 1937, they became associated with Messrs. Streamline Filters, Limited. Mr. C. J. Heffer continued as managing director until 1939. Mr. C. S. Garland, the present chairman, who presided at the luncheon, joined the board of directors in 1937. In recent years, Messrs. Caston have specialised in the construction of steel fire-protection doors for ships and large buildings, but during the recent war they were obliged to abandon this branch *pro tem.*, to concentrate on war work, largely for the Admiralty. Their first war contract was for 3,000 boom-defence buoys. They continued to construct buoys throughout the war, some weighing 2½ tons, but their war-work became steadily more various, including ammunition lockers, radar target buoys, filter containers, tanks of many kinds, parts for landing barges, mine-laying gear and torpedo-tube mountings, etc. Since the war, they have been able, not only to resume their pre-war activities, but, as a result of war-time experience, to branch out in new directions with welded and fabricated metal-work.

The Building Exhibition.

The influence of engineering and scientific research is increasingly apparent in the building industry. New materials are being introduced, and the application of improved methods of construction is encouraged owing to the shortage of labour. These trends are exemplified by the exhibits at the 22nd Building Exhibition, which was opened at Olympia by the Minister of Works, Mr. Charles W. Key, M.P., on Wednesday, November 19. The Minister said that the exhibition coincided with the introduction of incentives for employees in the industry, and he welcomed the contribution that the industry could make to the export drive, both in the sale of equipment to overseas buyers and, indirectly, in the building of factories. Government establishments were developing techniques which it was the responsibility of architects and builders to apply. The Minister was introduced by the chairman of the exhibition, Sir Lancelot Keay, President of the Royal Institute of British Architects. The exhibition, which was last held in 1938, will remain open daily from 11 a.m. to 9 p.m., except Sundays, until December 4. The Ministries of Works and Health, and the Department of Scientific and Industrial Research, have arranged a joint exhibit, which shows, *inter alia*, comparative tests of different materials for heat and sound insulation, efficient heating with solid-fuel appliances, and new types of mechanical equipment for use on building sites. There are many exhibits of engineering interest on manufacturers' stands. The assembly hall for the Bristol "Brabazon" aircraft contains a considerable area of roof and wall glazing, which is constructed with aluminium-alloy frames incorporating expansion devices, and examples of this form of construction are exhibited. A 3-cubic-yard tilting concrete mixer exhibited is believed to be the largest manufactured in this country. Aluminium alloys are also to be seen in use for roof trusses, roof sheeting, telegraph poles, and there are many examples of prefabricated house construction. Londoners will be interested in an exhibit entitled "This Was London," which is a collection of photographs, paintings and sketches of historic London buildings. The directors of the Exhibition are Mr. H. Greville Montgomery, and his son, Mr. Hugh Montgomery.

LETTER TO THE EDITOR.

CREEP AND SHRINKAGE IN REINFORCED CONCRETE.

To the Editor of Engineering.

Sir,—In his letter published on page 375, *ante*, Dr. Hajnal-Kónyi shows, contrary to my conclusion in the British Association paper on Creep and Shrinkage in Reinforced Concrete Structures (page 309, *ante*), that the adoption of a modular ratio of 27 in the design of reinforced-concrete columns would lead to a less economical use of this structural material. He suggests also that present methods of design, based on a modular ratio, should be abandoned in favour of an ultimate strength or plastic theory.

Considering, first, the use of a higher modular ratio. Suppose we design a column with 2 per cent. reinforcement for a working stress in the concrete of 1,140 lb. per square inch and a modular ratio of 15. In this column the effects of creep and shrinkage will ultimately increase the effective modular ratio to 27, and the steel stress at this time (approximately one year after loading) will be 26,000 lb. per square inch. If a stress of this order is to be allowed in the columns designed with a modular ratio of 15, it is only reasonable that an equal stress be utilised in columns designed with any other modular ratio. Thus we could design the above column in two ways: (1) using $m = 15$ with a maximum working stress in the concrete of 1,140 lb. per square inch, and (2) using $m = 27$ with a maximum working stress in the steel of 26,000 lb. per square inch. Both these methods will give the same result; the two columns will be identical and the stresses developed will be the same at all times. With a good quality concrete, therefore, neither method has any economic advantage.

Now suppose the concrete is of poorer quality and the maximum allowable working stress is 750 lb. per square inch. If we design using a modular ratio of 15, the stresses in the concrete and steel after about one year will be only 635 lb. per square inch and 17,300 lb. per square inch, respectively. If, on the other hand, we use a modular ratio of 27, the corresponding stresses at this time will be 750 lb. and 20,400 lb. per square inch. This latter value is still very much less than the steel stress of 26,000 lb. per square inch developed in a good quality concrete column designed with a modular ratio of 15. The use of these higher stresses naturally leads to a smaller cross-sectional area and therefore to a greater economy in this case. A similar result can also be shown for reinforced beams.

As Dr. Hajnal-Kónyi points out, however, these results demonstrate the unsatisfactory nature of calculations based on a modular ratio, and, on this account, the desirability of adopting a method of design based on the ultimate strengths of reinforced members. This opinion I had already expressed in answer to a question by Professor A. D. Ross at the British Association meeting to which the paper was presented, as reported on page 256, *ante*. A sudden change in design methods, however, cannot be expected, and investigations have therefore been carried out at King's College, London University, during the past few years with the object of improving present-day procedure. These have shown the desirability of using a higher modular ratio in order that the stresses developed in a concrete structure throughout the greater part of its life should be equal to those envisaged in the original design. It is to some extent incidental, but nevertheless noteworthy, that a slight saving would be achieved simultaneously.

Yours faithfully,

H. B. Seed.

The Graduate School of Engineering,
Harvard University,
Cambridge 38, Massachusetts, U.S.A.
November 8, 1947.

Royal Statistical Society.—A new edition of the list of Fellows and Honorary Fellows of the Royal Statistical Society, 4, Portugal-street, London, W.C.2, corrected to June, 1947, has been published. Fellows of the Society can obtain copies on application.

THE DESIGN OF FUSED-PLUGS AND SOCKET-OUTLETS.

One of the great advantages of domestic electrical apparatus is its portability. This enables it to be moved from one part of a house or room to another and is, as is well known, secured by the employment of a socket-outlet, which is generally fixed to the wall, and into which a removable plug carrying two or three connecting pins is inserted. This plug, in turn, is connected to the current-consuming apparatus by flexible conductors. To secure the full advantages of this arrangement, it is obvious that there should be complete interchangeability between the plugs and socket-outlets in the same house; and better still, throughout the same district and even over the whole country. Such an ideal is, however, far from being realised, since both two-pin and three-pin plugs are in use, as are both round and flat pins. There are also numerous other minor variations. Most important, however, is the fact that, though British Standard specifications exist, which cover both two-pin (B.S. 372) and three-pin (B.S. 546) plugs and socket-outlets, a number of plugs and socket-outlets which are of non-standard design, construction and dimensions, are employed. Full interchangeability is therefore still to seek and, in fact, could be brought about only by making the specifications mandatory. This, however, is hardly practicable, since the number of plugs and socket-outlets installed runs into millions and their wholesale replacement would be impracticable on financial grounds alone.

Another phase of this matter, however, has given rise to a good deal of controversy during the past few years. This controversy arose directly from the Post-War Building Study No. 11 on Electrical Installations, which was prepared by a Committee convened by the Institution of Electrical Engineers and was published in December, 1944. In this Study some recommendations were made with a view to bringing about that simplification in house-wiring which, it was considered, would follow the general use of alternating current and such adjustment in tariffs as would permit only one meter to be used. The most novel of these recommendations was that a ring circuit should be carried through each room of the house in turn and, starting and terminating at a 30-ampere fuse, should be connected to as many as twenty socket-outlets on the way. It was also proposed that the plugs associated with these socket-outlets should be rated at 13 amperes and should contain a cartridge fuse. It was at first suggested that the existing 5-ampere three-pin standard plug should be up-rated to 10 amperes for this purpose. Later, however, it was decided that a completely new 13-ampere (3-kW) socket-outlet and fused plug with three pins should be adopted as an "all-purpose" standard. The reasons given for this decision were that the existing sizes of three-pin socket-outlets (2-ampere, 5-ampere and 15-ampere) had been found to be not altogether convenient; and that the absence of an intermediate size between 5 amperes and 15 amperes had contributed to the use of non-standard apparatus.

The recommendations of Post War Study No. 11 were endorsed in April, 1945, at a joint meeting of the Codes of Practice Committee for the Electrical Equipment of Buildings and the Sub-Committee on Appliances of the Electrical Installations (Study) Committee. The next important step was in July, 1945, when the British Standards Institution was asked by the Electrical Codes of Practice Committee of the Institution of Electrical Engineers to prepare a specification for the new 13-ampere plug. The Electrical Industry Committee of the British Standards Institution, to whom the matter was referred, at first took the view that the introduction of a new plug would cause confusion. They, therefore, favoured the up-rating of the existing 5-ampere plug and the insertion of a fuse in the "fixed portion" of the installation, so as to ensure that apparatus which was supplied through an existing unfused plug (which might be inserted in the up-rated socket) would be protected.

Up-rating, however, also proved to have many opponents, so that after the whole question had been

discussed exhaustively with the electricity supply authorities, manufacturers and other interested parties, the Electrical Industry Committee of the British Standards Institution reversed its previous decision and passed a resolution in favour of the preparation of a specification for a new 13-ampere plug. This resolution was accompanied by the proviso that it should be endorsed by the Wiring Regulations Committee of the Institution of Electrical Engineers. This endorsement having been obtained, the matter was referred, in January, 1946, to the British Standards Institution Committee on Plugs and Sockets for the technical details of an appropriate specification to be worked out.

At this point, however, another difficulty arose. As we have said, although the British Standard specifications specify round pins, flat pins are also employed. They are, indeed, favoured by a number of supply undertakings, especially in the north; and for many years the Incorporated Municipal Electrical Association have been urging their standardisation on the grounds that they make a better engineering job than the round pin. It was not surprising, therefore, that the Plugs and Sockets Committee of the British Standards Institution proposed that flat pins should be used in the new fused plug in order that it should be clearly distinguishable from existing plugs and should render it difficult for these plugs to be forced into the new sockets. They also went a step farther and, to distinguish the new standard flat-pin plug from those already existing, proposed that all the pins should be flat instead of the earth pin being of circular section as in the earlier patterns. They further decided against a design of plug in which the fuse is incorporated in one of the pins, on the grounds that the British Standards Institution have always held that the pins and the terminals, to which the outgoing wires are connected, should be in one piece to avoid overheating due to faulty contact between the two. A draft specification embodying these proposals was therefore prepared and, after the usual practice of circulating for comment had been followed, was published as B.S. 1363-1947, at the end of last June.*

Briefly, the new specification covers two-pole and earthing-pin fused-plugs and flush-mounted shuttered socket-outlets, not combined with switches, with a current-carrying capacity of 13 amperes, at pressures up to 250 volts. The fuse-links are to be of the cartridge type and are to comply with B.S. 1362. Both plugs and socket-outlets are to be designed so that the earthing pin cannot make contact with either of the current-carrying contacts in the socket-outlet and so that neither current-carrying pin can make contact with a current-carrying contact in the socket-outlet while either or both of the other plug pins are completely exposed. When the plug is withdrawn, the current-carrying contacts in the socket-outlet are to be automatically screened by shutters; and these shutters are not to be operated solely by the insertion of the current-carrying pins. The earthing pin is to make and break contact with the earthing socket-contact, respectively, before and after the current-carrying plug pins make and break contact with the current-carrying socket-contacts. The normal distances between the centres of the current-carrying plug pins and between the common centre line of the current-carrying plug pins and the centre of the earthing pins are to be 0·875 in., while the spacing of the socket-contacts is to correspond.

The base and cover of the plug and the socket-outlet plate are to be of tough non-ignitable material which will not soften when heated to a temperature of 85 deg. C., and are to be tested in accordance with the plastic yield test laid down in B.S.S. 488. The socket-outlet base is to be of similar material, or of vitrified ceramic, while the current-carrying parts are to be of brass, phosphor bronze and/or other suitable metal. The shutter is to be of tough non-ignitable material which, under normal conditions, will not distort sufficiently to impede its action. The fuse link, which is to be within the body, is to be mounted in contacts between the line terminal and the corresponding pin in such a way that it cannot be displaced when the plug is in use. This fuse is only to be replaceable after the plug has been withdrawn completely from the socket-outlet. The hand is to be completely protected from injury if the fuse should blow during the insertion or withdrawal of the plug; and the plug is to be so strong that it will not fracture should the fuse link burst. The plug pins are not to be slotted, but are to be shaped so as to facilitate entry into the socket contacts. The widths of the current-carrying and earthing pins are to be 0·25 in. and 0·312 in., respectively, with a tolerance of ±0·005 in. The thickness of both pins is to be 0·156 in., with a tolerance of ±0·003 in. Both the neutral and the earthing pins are to be integral with their terminals. One fuse contact is to be either in one piece with the terminal or connected to it in such a way that it cannot work loose, while the other is to be similarly connected to the plug pin. The socket-contacts are to be self-adjusting and to be provided with a terminal capable of accommodating one, two or three 7/0·029-in. conductors.

Both plugs and socket-outlets are to be capable of breaking a current of 17 amperes at 250 volts on an alternating-current non-inductive circuit. The procedure for testing this capability is to insert and withdraw the plug ten times in succession at intervals of 30 seconds, the speed of withdrawal being about 6 in. per second. The minimum pull necessary to withdraw the test gauge is to be 8 oz. Alternatively, the effectiveness of the contacts is to be determined by measuring the voltage drop across them. This is not to exceed 12 millivolts with a current of 13 amperes. The temperature rise with a current of 13 amperes is not to exceed 35 deg. C., while the pull necessary to withdraw a plug must be between 1½ lb. and 8 lb. It may be noted that the range for the 15-ampere plug with round pins is from 7 lb. to 18 lb.

The decision to standardise flat-pin plugs has not been reached without a certain amount of opposition. It has been argued that the only justification for their adoption is that they were favoured by the supply industry; and that that is not the case. It is further argued that a round pin is stronger than a flat pin of equivalent section and that when the latter is used it is impossible to provide such good safeguards against poor contact. Moreover, although the advantages of having a single size of plug are admitted, it is considered that the round pin should continue to be employed, partly because it is already so largely used and partly because it will be some time before a flat-pin plug can be placed on the market in sufficient quantities. It is pointed out, too, that a 13-ampere fused plug with round pins is already being made, a particular feature of which is that the fuse is contained in one of the pins. The advantages claimed for this arrangement are that the plug does not have to be taken apart for the fuse to be changed and that wire cannot be substituted for the cartridge. It is also claimed that the cost of production of such a plug is substantially lower than that of the new standard fused plug. On the other hand, supporters of the flat-pin plug point out that the chief reason for its adoption is that it renders it impossible for existing non-fused plugs, whether standard or non-standard, to be inserted in the new socket-outlets. It is also considered essential that the pin and terminal should be in one piece, a condition which is not fulfilled when a fuse is inserted in the pin.

It will be clear from what has been said that the decision (upon the merits of which we do not propose to pronounce) to adopt a new standard 13-ampere flat-pin plug for use on ring circuits, though it may have been inevitable and is in accordance with the wishes of the majority, does not do much to bring the ideal of complete interchangeability nearer. Compulsion in this direction being unthinkable, interchangeability could only be brought about by a campaign directed towards persuading the consumer to make the change voluntarily. Such a campaign could not wisely be undertaken with the production position as it is at present. We hope, however, that if and when it is launched it will be accompanied, if not preceded, by efforts which will ensure the elimination of a great deal of apparatus which is not only non-standard but dangerous.

* "Fused-Plugs and Shuttered Socket-Outlets." London: British Standards Institution. [Price 2s. 6d. net.]

THE IRON AND STEEL INSTITUTE.

WE gave, on page 471, *ante*, a brief report of the opening proceedings of the annual autumn meeting of the Iron and Steel Institute, held in London on Wednesday and Thursday, November 12 and 13, and we deal below with the reading and discussion of papers at the meeting. Dr. C. H. Desch, F.R.S., the President of the Institute, occupied the chair.

HYDROGEN IN STEEL.

The first two papers considered, after the conclusion of the official business on Wednesday morning, were taken together for the purpose of discussion. The first was entitled "Hydrogen and Transformation Characteristics in Steel," and was by Professor J. H. Andrew, Dr. H. Lee and Messrs. H. K. Lloyd and N. Stephenson. The second paper, which was by Dr. C. Sykes, F.R.S., and Messrs. H. H. Burton and C. C. Gegg, was on "Hydrogen in Steel Manufacture." A joint discussion on these two papers was held during the special summer meeting of the Institute in Zürich, and we gave, on page 89, *ante*, brief summaries of the contents of the two contributions. It may be re-stated, however, that the first paper dealt with a comprehensive study of the evolution of hydrogen from 22 different commercial steels which had been soaked in hydrogen at 1,100 deg. C., and cooled in vacuum under identical conditions. In all cases relations between hydrogen evolution and transformation characteristics had been found to be marked and there was a pronounced increase in the rate of evolution corresponding to the γ to α change. It was considered that hydrogen embrittlement and hair-line cracks were closely associated with each other, and that hydrogen diffusivity and solubility were the controlling factors for both. While, however, hydrogen was the fundamental cause of hair-line cracks, stresses were important in that they might affect the diffusivity and solubility of the hydrogen.

In presenting the paper on "Hydrogen in Steel Manufacture," Mr. H. H. Burton stated that a number of determinations had been made of the hydrogen content of plain-carbon and alloy steels at different stages of manufacture. The experiments on semi-finished products had confirmed the results of previous work and indicated that ductility was reduced with hydrogen contents in excess of 2 c.c. per 100 grammes. Even when steel was melted under carefully-controlled conditions, hydrogen contents of from 4 c.c. to 6 c.c. per 100 grammes were to be expected and these would adversely affect ductility if not removed. A study of the effects of various heat treatments on hydrogen contents and susceptibility to cracking had shown that relatively high hydrogen contents did not automatically lead to hair-line cracks.

Before inviting members to speak, Dr. Desch stated that the two papers before the meeting represented contributions to a discussion which had been going on for a very long time on a problem that had proved more complicated than had been expected. The discussion was opened by Mr. A. J. K. Honeyman, who stated that Professor Andrew and his co-workers would no doubt be particularly gratified that the work of Dr. Sykes and his colleagues had confirmed that when hydrogen was introduced deliberately in steel it had, in almost every respect, the same effect as when it was present in the normal course of manufacture. These papers might be said to have solved the practical problems in relation to hydrogen in steel. Dr. C. Sykes, F.R.S., who spoke next, dealing with the paper by Professor Andrew and his collaborators, said that these authors had introduced certain new ideas into their paper. They had stated, for example, that the rate of diffusion and the apparent solubility of hydrogen varied with the condition of the steel even in the α state. He found it difficult to understand how this could be, and he would like the authors to elaborate the matter.

Mr. T. M. Service said that when reading the papers, the thought had occurred to him that at one time nitrogen had been blamed for all the ills in steel. Subsequently, Sir Andrew McCance had said that non-metallic inclusions were to blame,

while, between the two wars, the Germans had done work on oxygen, considering it to be the great source of trouble. Now metallurgists were concerned with hydrogen! The figure for hydrogen in a steel made in an open-hearth furnace appeared to be lower than that for hydrogen in a steel by the basic electric process. Was there any reason for this? It was curious that all forgings for rotors in Germany were made from acid open-hearth steel, although, of course, they had plenty of basic open-hearth and basic electric steel at their disposal. Did they choose the acid open-hearth steel because the hydrogen content was low?

Dr. S. A. Main, speaking on behalf of his colleague Mr. E. W. Colbeck, stated that the latter was quite sure that hydrogen was definitely a factor in the production of hair-line cracks. At the same time, as Dr. Sykes and others had shown, the mere presence of hydrogen was not all that was necessary to produce hair-line cracks. If the actual amount of hydrogen present were the critical factor, it would be expected that someone would have obtained a correlation between hydrogen content and the incidence of flaws, but no such correlation had been found. In their works, at some time or other, every feature of steelmaking had been found to be associated with the formation of hair-line cracks, but when an attempt had been made to follow the matter up contradictions were usually met with and it had been found impossible to pin the occurrence of cracks to any particular feature of steelmaking.

Mr. H. H. Burton, commenting on the paper by Professor Andrew and his collaborators, said that he was surprised to find that these authors had come to the conclusion that hydrogen pressure was the cause of hair-line cracks, because it seemed that their evidence, and, indeed, their argument, fitted in just as well, if not better, with the idea that hydrogen embrittlement, combined with stresses due to transformation, segregation, and other factors, were the cause. The next speaker, Mr. D. A. Oliver, said that the question of whether hydrogen segregated was not yet answered with certainty. He believed that there must be micro-segregation, and metallurgists were indebted to some of Professor Andrew's earlier work for pointing out that, in certain circumstances, hydrogen might be a powerful segregating element. From the practical point of view there was some evidence which seemed to support this view. In manganese-molybdenum steel, banding, rich in manganese-molybdenum-iron complex carbides, seemed to occur infallibly in the presence of high hydrogen in the melt at the time of casting. This would show that, on a small scale, at any rate, hydrogen could function in some peculiar manner to cause alloy segregation. During the war, the question of hair-line cracks had loomed large, and he was indebted to Mr. Burton for valuable help on possible heat treatments to eliminate hair-line cracks. This work had been extended vigorously with very great advantage. In one particular case of the continuous production of alloy steel, they had adopted an anti-hair-line crack heat treatment at the forging stage, which took 110 hours but was 98 per cent. effective. If that period was reduced to 96 hours, only about 80 per cent. successes were obtained. It seemed, therefore, that there was a critical minimum period over which these heat treatments should be operated.

Dr. H. Lee, replying to the discussion on the paper by Professor Andrew, Mr. Lloyd, Mr. Stephenson and himself, said that Dr. Sykes had asked why the rate of diffusion and the apparent solubility of hydrogen varied with the structure of the steel in the α state. It was obvious that in a steel in the α state two major constituents, cementite and ferrite, were present. The diffusion of hydrogen through the mass must depend on the distribution and the state of division of the cementite particles. It had been suggested that they had rejected some of their earlier conclusions. He agreed, but this was because, with the passage of time, as new facts came to light, it was necessary to modify the views previously held. Dr. C. Sykes, in reply to the discussion on the paper by Mr. Burton, Mr. Gegg and himself, said, in answer to Mr. Service's question of why the hydrogen was lower in the open-hearth steel than in the arc-furnace steel, that a considerable amount of dissociation occurred in the arc furnace, which did not take place in the open hearth. He agreed with Dr. Main that it would be very desirable to devise some method of testing the susceptibility of casts, but, at the present time, it seemed to be very difficult.

Brittle Fractures in Mild Steel.

The remainder of the morning was devoted to the discussion of the following three papers: "Brittle Fracture in Mild-Steel Plates," by Mr. W. Barr and Mrs. C. F. Tipper, D.Sc.; "The Effect of the Manganese: Carbon Ratio on the Brittle Fracture of Mild Steel," by Mr. W. Barr and Mr. A. J. K. Honeyman; and "Some Factors Affecting the Notched-Bar Impact Properties of Mild Steel," also by Messrs. Barr and Honeyman. All three papers were presented by Mr. Barr, after which Mrs. Tipper emphasised the main points of the first paper. The authors of this paper stated that the temperature range of transition from tough to brittle fracture of mild-steel plates of different carbon and manganese contents had been determined by means of notched-bar impact, notched bend, and notched tensile tests. The results obtained by each of these different tests were generally in good agreement, except that, for very soft steels, the notched tensile test gave a lower transition range than the other two tests. It was found that the transition range was raised by an increase in the ferritic grain-size, by an increase in plate thickness and by slow cooling after normalising. It was also found that a high notched-bar impact value might be accompanied by a fracture which was mainly a cleavage. Tentative conclusions, subject to confirmation, had been reached that the effect of increasing plate thickness in raising the transition range was less marked in the plates having a high manganese content and that the effect of slow rates of cooling in raising the transition range was diminished in the plates having a high manganese content.

In their paper on the "Effect of the Manganese: Carbon Ratio on the Brittle Fracture of Mild Steel," Messrs. Barr and Honeyman stated that four mild steels, in which the only significant variable was the manganese: carbon ratio, had been made. The residual elements were low and the tensile properties were approximately the same for each steel. The notched-bar impact properties of the steels, in the annealed and in the normalised conditions had been determined. It had been found that increasing the manganese: carbon ratio lowered the range of transition from tough to brittle fracture, increased the impact values at all temperatures and tended to result in finer McQuaid-Ehn and ferritic grain sizes. A practical recommendation was made that for structural steels for shipbuilding purposes, the manganese: carbon ratio should be not less than 3·0.

The third paper, "Some Factors Affecting the Notched-Bar Impact Properties of Mild Steel," also by Messrs. Barr and Honeyman, described work carried out to confirm and extend conclusions, on the influence of carbon and manganese on the notch sensitivity of mild steel, previously arrived at by the authors. Steels for the tests had been made to carefully-controlled compositions and their structures and impact properties, in the normalised and annealed states, determined. It had been found that increasing the carbon content raised the transition range and lowered the impact values of steels in the normalised condition while the increase of manganese content had the opposite effect. It was confirmed that an increased manganese: carbon ratio tended to give a steel having a finer McQuaid-Ehn grain-size and a finer structure in the normalised condition. A comparison of steels made with and without a grain-controlling addition of aluminium, showed that the manganese: carbon ratio might be as effective as grain-size control in reducing notch sensitivity. A study of the relationship between the notched-bar impact value and the degree of cleavage in the fracture showed that the latter was not the best criterion by which to judge notch sensitivity. Material which gave a predominantly cleavage fracture would be satisfactory in service, provided that an appreciable amount of energy was absorbed before a crack was initiated.

The discussion was opened by Mr. H. H. Burton, who stated that one thing that troubled him in connection with the suggestion put forward by Barr and Honeyman for increasing the manganese content and also the manganese: carbon ratio was that their tests, showing the superiority of these compositions, were based, apparently, on examination of the plate material itself; in other words, the unwelded plates. They were based on the advantages shown by plates which had received a definite heat treatment; in this case it was a normalising treatment. There might be some danger in increasing the manganese content beyond a certain point, when the structure developed at the weld was taken into account, unless the weld were subsequently heat treated, which, in the case of ship's plate, appeared to be almost impossible. Those who had done work on manganese pearlitic steels having a manganese content of up to 1·5 per cent. knew that, in general, a tempering treatment was a more reliable method of increasing the impact value of the steel than was normalising. There were cases in which such a steel, in the as-rolled condition, gave an impact value of 6 to 7 ft.-lb. After tempering at 600 deg. C., the impact value was 100 ft.-lb.

Dr. I. G. Slater said that the experience in the United States with the "Liberty" and other ships which suffered brittle fracture had set in motion an enormous amount of work on both sides of the Atlantic, but it should be remembered that these phenomena had long been familiar to metallurgists. To summarise the position, it was fair to say that views in the United States were a long way from being crystallised and it was very obvious that we also had a long path to take before we reached any degree of finality. Giving instances of brittle fractures of boiler drums, chain links, forgings, studs and bolts, which had occurred in service, Dr. Slater said that a significant feature in these was the presence of stress raisers of considerable magnitude, such as a crack or deep corrosion pit or slag inclusion and sharp corners. Another significant feature was the presence of strain-age embrittlement in the steel area adjacent to the origin of fracture. The matter was not a simple one of a limited number of properties in a steel, but concerned the integration of a large number of properties.

Dr. N. P. Allen said that it was felt on all sides that a great deal of work was necessary before a full understanding of the phenomena of brittle fracture would be obtained and what Barr and Honeyman had to say was that, while the work necessary to elucidate these problems was going on it would not be a bad idea to keep the manganese content up and the carbon content down, remembering, however, the points which Mr. Burton had raised. The investigations had shown that the rate of cooling was important, a fact which was already known, but it should be emphasised that we did not yet know what was the rate of cooling which was important in this connection. The difficulty of studying the precipitations from the ferrite, occurring between 600 deg. C., and room temperature, which precipitations might very reasonably be the cause of some of the troubles encountered, was that, hitherto, it had not been possible to detect microscopically these very small particles which came out of solution. The progress on microscopic work at high magnifications was such, however, that there was reasonable hope that the range of useful magnifications available in metallography would go up to at least 5,000 or 10,000 diameters, and it would be possible to see particles which were not more than 100 or 200 rows of atoms in width. There was some ground for thinking, therefore, that it would be possible, in the near future, to conduct a metallographic investigation of these lower-temperature changes which everybody felt had something to do with the problem under discussion.

Mr. W. Lewis stated that the special value of researches of this kind lay not so much on the experimental data presented as in the recommendations of the authors on how the recurrence of these disadvantageous factors could be prevented, or at least minimised. The authors had put forward two recommendations. The first was to determine the notch sensitivity of the material by means of the rupture of a notched test bar. He preferred the second recommendation, namely, that the manganese: carbon ratio of the material should not be

less than 3. Upon hearing this, Lloyd's Register had proceeded to carry out a census of casts produced by the leading British rollers of heavy plates and intended for the Society's normal requirements. It had been interesting to find that, out of a total of 700 casts, 93 per cent. had a manganese : carbon ratio of 3 or over. He did not know whether the authors had arrived at their figure of 3 by a similar process but, if they had not, the British steelmakers were fortunate in having hit on this figure. One disconcerting matter was that the researches confirmed the authors' opinion that, all other factors being equal, the thicker the plates the greater the degree of notch sensitivity. This accorded with evidence obtained from the fracture of American plates. Whether the adoption of a minimum manganese : carbon ratio of 3 would obviate this, only time would tell.

Mr. J. Rosen said that Sir Amos Ayre, chairman of the Admiralty Ship Welding Committee, was unable to be present, but had asked him to present certain notes. Sir Amos wrote that while the Committee was naturally most anxious to arrive at a complete solution of the problem, they realised that they must be patient while the researches were going on. Meanwhile, however, they had reached the view that, for shipbuilding steel of normal thicknesses the manganese content should be three times the carbon content. If applied with reasonable tolerance, this recommendation should not entail any increase in cost to the consumer. Mr. J. N. Bradley, who spoke next, said that the authors tended to discount the importance of assessing the relative merits of mild-steel plates by their fracture in the notched-bar test. An assurance of a material's ability to resist crack propagation was afforded by the appearance of the fracture. It was surely just as important tto ensure that a crack, if propagated, did not spread in a catastrophic manner as it was to ensure resistance to the initiation of a crack. The next speaker, Mr. G. M. Boyd, stated that the fact that notch effects, even in the best design, material and workmanship, were almost inevitable, must be faced. This being the case, resistance to further development of the cracks was of paramount interest, and resistance to initiation fell to second place. The authors appeared to imply that if a notch effect were sufficiently severe as in the case of an incipient crack, brittle fracture was inevitable. There was considerable evidence to support the view that there was a resistance to propagation as distinct from resistance to initiation of the crack which distinguished a ductile steel from a notch-brittle steel. The last speaker, Dr. S. A. Main, said that if in the construction of a ship, or other structure, the steel were "tied up" and its possibilities for displaying its ductility constricted, how could it be expected, when it did fail, to give anything but a brittle fracture? It was possible in the laboratory, by using the right means, to put a brittle fracture into the best of mild steel.

In a brief reply, Mr. A. J. K. Honeyman said that his colleagues and himself had set out not to solve the problem, but to give the shipbuilders a practical suggestion which would reduce, not completely eliminate, the incidence of sudden fractures in steels, without, however, increasing the cost of the material. In practical shipbuilding, with almost every plate over ½ in. thick, if it broke at all in the presence of a notch, it would break with a brittle fracture. What was necessary was not to let a crack take place. This could be done by decreasing the notch sensitivity and this was accomplished comparatively cheaply by increasing the manganese : carbon ratio.

(To be continued.)

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—An Institution Scholarship, of a maximum value of 130*l.* per annum and tenable for not more than three years, will be offered for competition in the summer of 1948, by the North-East Coast Institution of Engineers and Shipbuilders. Candidates must be students of the Institution, and the closing date for entries is March 1, 1948. Applications for student membership from intending candidates must be submitted not later than January 9, 1948. Further information regarding the examination and scholarship are obtainable from the secretary of the Institution, Bolbec Hall, Newcastle-upon-Tyne, 1.

INTERNAL STRESSES ARISING FROM TRANSFORMATIONS IN METALS AND ALLOYS.*

By PROFESSOR F. C. THOMPSON, D.Met., M.Sc.

THAT the imposition of mechanical stress affects the rate of reactions in alloys is well known : cold-working a material before heat-treatment, for instance, accelerates most markedly the velocity with which equilibrium is attained. It is the object of this note to point out some of the effects of internal stresses set up by the heat-treatment itself, and their influences on the resulting structure. As Benedicks has shown, even such a transformation as the A_3 point in iron, which involves no change in the space-lattice in which the material crystallises, is associated with a small, but still measureable change of volume. Further, even where a close-packed cubic lattice is transformed ideally into an equally close-packed hexagonal one, the actual process of transformation involves a temporary volume change arising from the distortion normal to the direction of atomic movement, and due to the atoms riding over others in the course of their translation from their original to their final positions.

Where the lattice is altered by the transformation, this volume change may be appreciable, that from the face-centred to the body-centred cubic structure, for instance, representing an expansion of some 9 per cent. If there were no relaxation of stress due to twinning or plastic flow, and, therefore, if the stresses set up were retained in their entirety, this, in the case of iron (if the change occurs at around ordinary temperatures) would involve the setting up of an internal stress of the order of some 450 tons per square inch. It is in the case of the change points in steel that this type of phenomenon has been longest and most carefully studied.

It is a most curious fact that when a very high plain-carbon steel is quenched from a very high temperature, the unchanged austenite occurs in the centre of the specimen, where the cooling rate must inevitably have been slowest, while the surface, which cooled most quickly, is entirely martensitic. Broadly, the hypothesis suggested is based on the fact that when martensite is formed, it necessitates a large expansion. At the normal free surface, this can occur without hindrance, and here, therefore, the transformation proceeds to completion. The formation of this martensite—at a comparatively low temperature, say, 300 deg. C. or less—produces a comparatively rigid skin which resists the stresses set up as further change occurs. The breakdown of the austenite is therefore progressively retarded, until, when a sufficiently thick skin has been produced, further change is inhibited. That this is, in fact, so was demonstrated by first heating the sample of steel in carbon to a temperature in excess of the eutectic temperature, and for a time sufficiently long to produce a thick, superficial layer of white cast iron. When this composite specimen was subsequently quenched, the austenite was retained right up to the surface of the steel, the white iron shell now acting as the rigid layer, which inhibits expansion. When a sample, originally containing structurally free austenite, is sectioned, polished, and allowed to stand, the now unrestrained surface gradually undergoes transformation, the formation of martensite from the retained austenite being demonstrated by a well-marked relief effect.

In their study of the isothermal transformation of austenite at temperatures such that martensite is the product, Thompson and Stanton† reported that on immersion of the steel specimen—in an austenitic condition—into the liquid metal quenching bath, breakdown at the surface occurs almost instantly, without the period of induction normally characteristic of the process. This momentary expansion is followed by the long incubation stage during which further breakdown takes place at an immeasurably slow rate, if at all.

The explanation suggested is identical with that due to Benedicks, transformation proceeding immediately and without interference at the unrestrained surface, thus producing a skin which retards further change. On continued immersion, stress relaxation is to be expected and, as a result, renewed and progressive transformation. It was further suggested that the rate of reaction should be accelerated by the application of a tensional stress to the specimen while actually in the quenching bath. Unpublished results subsequently obtained by M. D. Jepson, have shown this to be substantiated. By the application of a tensional stress of the order of 10 tons per square inch while the specimen is in the molten metal at 200 deg. to 400 deg. C., the time required for a eutectoid, plain-carbon steel to undergo essentially complete change is practically halved.

The importance of the free surface of the specimen can hardly be overstated. Its significance in connection with the mechanical properties has already been pointed out by Thompson and Millington, in 1924, and there is clearly a close correspondence between these and the stresses which may be set up during transformations. The size of the sample is, therefore, a matter of supreme importance. As this increases, the possibility of stresses being produced of a magnitude sufficient to effect further changes must clearly increase. This effect of free surface is very clearly demonstrated at cracks produced by the quenching stresses. At and around these, it is common knowledge that the breakdown of the austenite has proceeded distinctly further than in the main body of the sample.

Wassermann has shown that the lattice constant of an age-hardening aluminium alloy when quenched, increases with the diameter of the sample. The considerable differences in lattice constants found are to be explained by the presence of quenching strains. In the case of aluminium itself, the variation with diameter is much smaller (as would be expected as a result of the lower elastic limit of the pure metal). Further, the tensile strength of wires of an aluminium-copper alloy containing 4·8 per cent. copper, when quenched and aged, at first increases with diameter and then decreases.

It is germane here to point out that McCance suggested in 1914, with considerable plausibility, that the hardness of a quenched steel may—in part at any rate—be attributed to the extremely severe strains set up in the α-iron. This effect is not the whole story, as the state of extreme supersaturation of the carbon in solution in the α-iron must clearly be playing a substantial part. It is, however, a question which is worthy of much more attention than it has so far received. No better proof of the real existence of transformational stresses can be desired than evidence of mechanical twinning.

If martensite is formed from austenite as a result of internal stresses set up by the quenching operation, such stresses first initiating mechanical twinning, and then immediately leading to a change in the lattice, an important corrolary appears to follow which has not hitherto been pointed out. The higher the stress required to start the process, *i.e.*, to cause mechanical twinning in the austenite, the higher will be the quenching stresses needed to cause martensite formation. In other words, the stronger the austenite under a given set of conditions, the more stable will it become. This conclusion, if justifiable, would appear to be of immense importance in connection with many forms of heat-treatment of the alloy steels.

In this connection, it may also be pointed out that a relationship has been suggested between the duration of the incubation period during isothermal treatment and the creep strength of the steel. It will have been noticed that the main part of the evidence for the inter-relationship of stress and transformation has so far been drawn from the high-carbon steels. This is inevitable, since with softer materials, *i.e.*, those of lower elastic limit, the maximum stress which can be induced is necessarily lower, and the effects, therefore, in general far less pronounced.

Even so, however, there are many instances in which strain effects, not due to any externally applied stress, are to be observed. Greenwood has shown that chill-cast cadmium readily undergoes spontaneous recrystallisation, and Cook has published micrographs showing markings suspiciously like the mechanical twins known to occur in this metal, again in the chill-cast state. In the case of zinc the effect is even more strikingly marked, as was shown, in 1920, by Bingham. The similarity to mechanical twins could hardly be more pronounced, and the work is of special interest in that it was carried out on material of high purity in which, therefore, the danger of impurities affecting the results is absent. According to this worker there is a sudden change in the specific gravity of about 0·08 at about 170 deg. C., amply sufficient to set up elastic stresses exceeding those required to produce twins in this metal.

Age-hardening phenomena in aluminium alloys have also been shown quite definitely to be connected with stress effects. Wassermann, among others, has published excellent photographs of the strain markings produced in an aluminium-copper alloy as a result of the quenching. He has further shown that on these markings, ascribed by him to mechanical twinning, subsequent precipitation of $CuAl_2$ occurs preferentially. The effect is strikingly similar to the preferential precipitation of the carbide from the needles of martensite when a steel quenched from a high temperature is tempered. Finally, there is by now a considerable body of evidence to show that the first stages of precipitation of metallic phases from solid solution may differ very markedly from the equilibrium conditions. How far this is due to the state of strain which inevitably arises in the lattice, or to diffusion effects is not yet, however, clear.

* Paper presented before the "Symposium on Internal Stresses in Metals and Alloys," organised by the Institute of Metals and held in London on October 15 and 16, 1947. Abridged.

† *Jl. I. and S. Inst.*, vol. 151, p. 133 (1945).

ANNUAL REPORT OF THE ELECTRICITY COMMISSIONERS.*

THE 21st annual report of the Electricity Commissioners, which was published last week, covers the year ended March 31, 1946. It has therefore to be followed by one dealing with the occurrences of the subsequent twelve months and, we hope, by yet another in which a review will be given of the operations of a body that has deserved well of the industry. After that it will, of course, be necessary to look to the new Authority for such information on electrical development as it is thought fit to make public.

The present document suffers from a certain air of unreality. The main reason is that it deals with a period which ended 18 months ago; and much has happened since then which is only too familiar. Statistics of a later date have been published also. It is, moreover, concerned with a period of transition and of restrictions on development which are of course continuing and are interfering with normal progress. Priority had to be given to supplies to new houses, farms and public services, those to other classes of premises being permitted only in so far as surplus labour and materials allowed. In the early part of the year under review it also became apparent that the generating plant available would not be sufficient to meet any substantial increase in maximum demand. Load shedding during the following two winters was an obvious possibility and ways of mitigating this by transferring load from the peak periods, by securing voluntary reductions and by the use of private generating plant had to be devised.

Apart from the Central Electricity Board, 568 undertakings in Great Britain held powers to supply electricity on March 31, 1946. These undertakings generated 37,284,597,992 kWh in 346 stations and consumed 22,821,088 tons of coal and coke and 19,471 tons of oil fuel. This output was 1,078 million kWh, or 2·8 per cent., less than in 1944, and the amount of coal and coke showed a corresponding decrease of 626,853 tons, or 2·7 per cent. Steam plant accounted for 96·81 per cent. of the total output, and the average number of kilowatt-hours generated per ton of coal and coke consumed was 1,578, compared with 1,582 in 1944. Of the 346 stations, 118, or 34·1 per cent., generated less than 1,000,000 kWh during the year, while 145 stations, or 42 per cent. of the total, generated over 1,000,000, but less than 100,000,000 kWh. The remaining 83 stations with individual outputs of 100,000,000 kWh, or over, were collectively responsible for an output of about 34,533 million kWh., or 92·63 per cent. of the total. There were 142 "selected" stations in the nine scheme areas, an increase of one over the previous year, and of the total output of 37,825 million kWh generated in 1945, 35,776 million kWh, or 96 per cent., were generated in these stations.

Of the applications received by the Commissioners during the year for consent to the establishment or extension of generating stations, the most important were those relating to the provision of new selected stations and of additional plant at existing selected stations for the purposes of the grid. The aggregate capacity of generating plant sanctioned during 1945-46 for a new station and for extensions was 917,475 kW, compared with 1,179,400 kW in the previous year. It is interesting to note that, since January 1, 1920 (when the Commissioners began operations), consents to the erection of 2,088,153 kW in new stations have been given, while the aggregate capacity of the plant installed in existing stations has been 12,187,979 kW, a total of 14,276,132 kW. The total amount of generating plant actually installed at the end of March, 1946, was about 12,000,000 kW, this figure being exclusive of plant replaced or taken out of commission as obsolete. It should be pointed out in this connection that the figures relating to new generating stations represent the capacity of initial installations only. The capacity of any additional plant subsequently installed in such stations is included in the figures relating to extensions. Of the generating plant sanctioned during the past 26 years, about 62·1 per cent. was for stations belonging to public-authority undertakings; about 32·7 per cent. for stations owned by companies, and the remainder in stations belonging to railway and tramway authorities and non-statutory undertakings.

During the year ended March 31, 1946, six consents were issued to the establishment or extension of main transmission lines by the Central Electricity Board and other authorised undertakings. The consents issued to the Central Electricity Board covered the construction of about 27 miles of primary grid lines at 132 kV, and about two miles of grid lines at 33 kV. The consents issued to other authorised undertakings covered the construction of about 17 miles of 66-kV lines, three miles of 33-kV lines, and 14 miles of 25-kV lines.

* *Twenty-First Report of the Electricity Commissioners.* London: H.M. Stationery Office. [Price 2*s.* 6*d.* net.]

LABOUR NOTES.

THE writer of the editorial notes in the November issue of the Amalgamated Engineering Union's *Journal* says that discussions which have taken place with Sir Stafford Cripps as Minister of Economic Affairs and other Ministers concerned with the implementation of the export programme, have shown that the Government is fully aware of the need to bring the trade unions into the closest co-operation with them. "It must be recognised, however," he goes on, "that the existing machinery of co-operation in industry is not as extensive and as efficient as it should be. Members of our Union know that we have constantly urged the necessity of extending the machinery of Joint Production Committees. It has not been done on a sufficiently wide scale even in our own industry, for which a national agreement on the subject was negotiated very early in the war. In other industries, it has hardly been done at all."

"Yet," he continues, "every worker in the engineering industry knows from his own practical experience that scarcely any plant in the industry is working to full capacity with 100 per cent. efficiency in every department. This view is relevant to the production questionnaire put out by the Confederation of Shipbuilding and Engineering Unions. We all know that enormous savings can be effected by better planning in the supply of materials, tools and machines, with a more intelligent lay-out in the shops, and in the elimination of waste. In the old days, trade unionists were rightly hostile to what was called scientific management. But, the well-founded objections we had, as trade unionists, to the scientific technique that was involved by time and motion studies to increase output have lost much of their weight in present circumstances."

"We ought not," the writer of the note says, "to shut our eyes to the necessity of examining workshop methods, layouts, and planning to avoid unnecessary waste—waste of time, waste of work, waste of materials, waste of fuel and power. We have to rely upon our members to give us that practical experience in these matters, in the shops, through the shop stewards, branch officers, and union representatives on Joint Production Committees. We want the active interest of individual members engaged and the union machinery effectively used to improve the conditions of efficiency in the shops and thus to contribute to an increase in production."

The membership of the Amalgamated Engineering Union at the end of October was, according to returns received at the head office from branch secretaries, 820,719. This represented an increase of 6,112 compared with the position at the end of September. During October, 5,266 members received sick benefit—an increase of 473, and superannuation was paid to 19,794 members—an increase of 66. Unemployment benefit was paid to 891 members—a decrease of 28—and the total number of unemployed members was 3,211—a decrease of 69.

The Amalgamated Society of Woodworkers, it may be recalled, was the only unit of the National Federation of Building Trades Operatives to reject the incentive-payment system proposed by the Minister of Labour and National Service. In a ballot, 39,350 members voted against acceptance of the system and 20,954 in favour of it. The issue was, however, decided by the pooled vote of the affiliated unions, which was 165,606 for acceptance and 77,868 against acceptance. In fulfilment of the Society's obligations as an affiliate of the National Federation, the General Council have now accepted the system under which certain bonuses become payable, standard craft rates are increased by 3*d.* an hour, and the wage rates of labourers are adjusted proportionately. With the approval of the National Joint Council for the industry, the arrangements took effect early this week.

In a circular dealing with the matter, issued by the Woodworkers' General Council, it is pointed out that the union is "bound" by any decisions of the National Joint Council for the industry and of the National Federation of Building Trades Operatives. The only alternative, it is stated, to acceptance of the agreement would be withdrawal from the Federation, which would become effective only after sixteen months. That, it is declared, would be disastrous, as the union could not stand alone, or compel the employers to enter into a separate agreement. It is, therefore, proposed, the Council add, to suspend the union rule forbidding bonus payments, and to work the agreement, which is binding, for a trial period of two years.

In the House of Commons on Tuesday last week, the Minister of Labour and National Service said that he had "that day made an Order under Defence Regulation 58A, as extended by the Supplies and Services (Extended Purposes) Act of 1947." The Order, he explained, would give power to require the registration of persons who were unoccupied or who were following certain occupations. The age limits were the same as those imposed by the Control of Engagement Order, 1947, and the occupations, employment in betting and gambling, including football pools, and amusement arcades, night clubs, and street trading in urban areas.

Continuing, Mr. Isaacs said that there would be two methods of registration. Under one method, individuals would be called upon to register personally; under the other, employers would be called upon to register particulars of their employees. After registration, the persons registered would be called to the Employment Exchange for interview and dealt with in exactly the same way as persons seeking employment under the Control of Engagement procedure. That meant, he observed, that in appropriate cases they would be offered employment on essential work, and, if necessary, formally directed to it. The Order is expected to come into force on December 8.

After discussions which lasted for two days, representatives of the National Coal Board and representatives of the executive of the National Union of Mineworkers, reached an agreement on the wages question last week. The unions claim was for an all-round increase of 20*s.* a week. Under the new agreement—acceptance of which was recommended by the men's executive to a national delegate conference on Thursday this week—underground day workers will receive an increase of 15*s.* a week and rates will be adjusted to yield a similar advance for piece workers. Surface workers are to receive an increase of 10*s.* a week. The weekly wage of the adult underground workers will, therefore, now be 5*l.* 15*s.*, and that of surface workers 5*l.* The estimated cost of the Coal Board's concession is about 13,000,000*l.* a year. The new rates are to have effect as from the beginning of the current month.

A special effort is to be made to increase the industry's man-power, which has been decreasing in recent weeks. The union has agreed to the recruitment of 30,000 European volunteers next year. Ten thousand boy orphans in Displaced-Persons camps in Germany are also to be enlisted.

Addressing a Press Conference in London last week, Sir Godfrey Ince, Permanent Secretary of the Ministry of Labour and National Service, described the increase that has taken place in the number of persons engaged in Britain's export industries as "spectacular." Seventy-four per cent. more persons, he said, were employed in that way than in mid-1939, when the figure was 990,000. From 1,588,000 in August this year, the figure rose in September to 1,719,000. The inference was, he claimed, that we should have sufficient persons in the manufacturing industries to achieve a 40 per cent. increase in the volume of exports—which was the Governments target for early next year.

The increase was mainly due, Sir Godfrey said, to two causes. One was the switch over of production from the home market to the foreign market, involving 72,000 employees, and the other, the recruitment of 59,000 additional persons by the manufacturing industries. Of the increase of 131,000, 81,000 were in the metal, engineering, chemical and allied industries, and 50,000 in other industries.

Alluding to the steel industry's record weekly output of 281,400 tons, the writer of "Notes and Comments" in the November issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, says: "It must be stressed that this production record was broken not by men who had received privileges or favours in the shape of extra rations and food parcels, but by men who, at a time when some people were enjoying the luxury of a five-day week, agreed to put into operation a 48-hour continuous week. Nor is it an isolated effort, but a steady and sure progression, in the face of great difficulties, towards the Government's target figure of 12,500,000 tons for 1947."

The Ministers concerned are, he goes on to say, grateful to the industry for "its magnificent effort." "If the Government," he continues, "in a form more tangible than mere words, would show more gratitude to the men who are actually doing the job, instead of granting favours to some in the hope of getting something in return, then the workpeople in the steel industry would also have something for which to be grateful. Few jobs require greater physical effort than the steelworker's, and it is about time this was recognised."

THE MANUFACTURE OF CAST-STEEL BOMB-BODIES.*

By Percy H. Wilson, O.B.E., M.I.Mech.E.

During the first few months of the war it became apparent that the tonnage of bombs which would be required by the combined air forces was very much greater than the potential capacity of the then existing steel foundries and other works capable of producing bomb bodies. The Ministries concerned, therefore, approached various manufacturers with the object of setting up suitable shadow factories for the sole purpose of producing steel bomb bodies. One of these plants was that built within the works of the Stanton Ironworks Company, Limited, and known as the Stanton Gate Foundry, which, as the war progressed, became the largest single source of supply of 500-lb. cast-steel bomb bodies. Longitudinal sections of finished castings of the two types of bomb bodies made are given in Figs. 1 and 2, on this page. Fig. 1 shows a 500-lb. general-purpose bomb body and Fig. 2, a 500-lb. short medium-case bomb body. The plant, which continued in operation on the production of 500-lb bomb bodies for four years, was designed jointly by the Stanton Ironworks Company, Limited, and H. A. Brassert & Company, Limited, the former being responsible for the design of the principal production unit, *i.e.*, the foundry, while the latter dealt with the melting and machine shops.

It was decided that the factory should be capable of a continuous production of bomb bodies at the nominal rate of 100 per hour and in its design certain important factors, due to conditions imposed by war, had to be considered. At the outset it was realised that the type of male labour usually employed in steel foundries would be in short supply. In consequence, all possible operations were mechanised, and wherever practicable, the plant was designed so as to be capable of operation by female labour. The raw-materials supply position had also to be considered as, due to the shipping position, it was necessary to limit the imports of hematite iron and ferro-alloys. The layout of the steel plant and the steelmaking process adopted was arranged so as to minimise the use of these materials, and after the plant had been in operation a few months, the use of hematite iron was, in fact, entirely discontinued, and the consumption of ferro-silicon in the cupolas and in metal charged into the converters was reduced to a figure not exceeding 0·25 per cent. in the cupolas and about half this amount in the converters.

The steelmaking plant and equipment were housed in two adjacent bays each 510 ft. long by 147 ft. wide, one of which contained four cupolas and blowers; two 12-ton rotary furnaces with ancillary pulverised-fuel equipment; and four 3-ton side-blown acid-lined converters with separate blowers, together with storage space for bricks and other refractory materials and pits to accommodate the rotary furnace shells and converter bodies during relining. The second bay was used exclusively for the storage and preparation of raw materials, and cupola-charging equipment.

The steelmaking process was a definite departure from previously recognised practice, and its adoption provided the first instance of the use of this process on a commercial scale. In principle, it consisted of the melting and recarburising of selected steel scrap in cupolas, the desulphurisation of the melted metal by treatment with soda ash, followed by the superheating of the metal in rotary furnaces and the direct conversion to steel of the low-silicon metal in side-blown Tropenas converters. The following paragraphs describe in some detail the type of plant used, and the methods adopted for the production of molten steel of the requisite composition for the casting of the steel bomb bodies.

The steel scrap consisted of rails, girders, drop forging scrap, billets, crop ends, stampings and scrap shells which were used with a proportion of circulating scrap consisting of heads, runners and scrap bombs. Each truck was sampled and analysed for sulphur and phosphorus before cutting to suitable sizes. The general basis of acceptance was a phosphorus content of 0·08 per cent. maximum, but this varied with the phosphorus content of the bulk of the delivery at any one period. Some of the material contained less than 0·02 per cent. phosphorus, and it was all carefully mixed to give an average charge containing 0·05 per cent., consistent with physical condition to avoid scaffolding and loose or too close packing in the cupola. For this purpose, long rails and girders were cut to lengths of 2 ft. 6 in. by oxy-gas burners, the oxygen being piped into the scrap bay from a liquid-oxygen evaporator plant. Two railway lines running the length of the raw-materials bay enabled 25 wagons to be available for simultaneous unloading into the charging skips to give the desired chemical and physical charge composition for a whole shift.

There were four drop-bottom cupolas of the balanced-blast type designed to give maximum carbon pick-up to the charge. The constructional details were as follows:—

Height, tapping hole to top of stack...	47 ft.
Height from tapping hole to charging sill	25 ft. 6 in.
Diameter of shell	11 ft. 3 in.
Thickness of lining	1 ft. 10½ in.
Working diameter	7 ft. 6 in.
Height from tapping hole to tuyere level	4 ft. 3 in.
Number and diameter of tuyeres:	
Main	16 — 8 in.
Auxiliary	16 — 2½ in.
Secondary	8 — 4 in.

The charge consisted of 4,000 lb. of steel scrap, 20 lb. of 45 per cent. ferro-silicon, 672 lb. of coke, and 100 lb. of limestone. The bed coke weighed 5 tons 16 cwt. The addition of ferro-silicon was made in order to ensure fluidity of the metal tapped from the cupola, especially at the beginning of the shift. This part of the plant commenced production before the rotary furnaces were completed, and during this period the cupolas operated on a hematite/steel mixture using up to 30 per cent. of hematite, according to its silicon content. The coke ratio was adjusted accordingly, the limits being 8 metal : 1 coke with the 70/30 mixture, to 6 metal : 1 coke with 100 per cent. steel scrap. The metal charge was loaded into bottom-opening skips, carried on suitable bogies, by means of a 7½-ton magnet crane in the loading bay. These were shunted by a battery-operated locomotive to the charging bay, the weight being checked *en route*, and were then picked up by an overhead travelling crane and discharged into the cupola by the opening of the drop bottom. The coke and limestone were emptied by hand from railway wagons into similar skips and charged into the cupola. Two magnet cranes and two charging cranes were necessary in order to cope with the rate of melting.

Fig. 1.

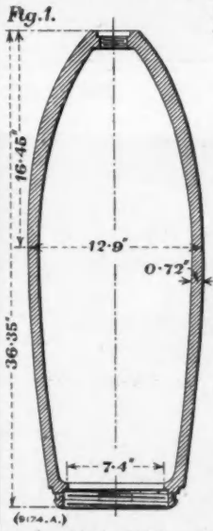
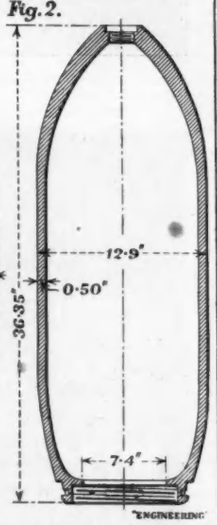


Fig. 2.



The cupolas were blown by Holmes-Connersville positive blowers, having two chambers 24 in. by 60 in., giving a maximum output of 18,000 cub. ft. per minute at 54 in. water gauge. The volume of air used was between 9,000 and 12,000 cub. ft. per minute, at which the melting rate was 16 tons and 22 tons per hour, respectively. During one shift an average rate of production of 123 castings per hour was maintained throughout the shift, and during this period the average output of the cupola was 22 to 23 tons per hour. The general scheme of working was to start the cupola at 6 p.m., and blow continuously through the night shift and the following day shift to 4 p.m., namely, 22 hours. During the week two single shifts of 11 hours were worked, namely, Monday day and Friday night. On three occasions immediately prior to a holiday period, the shifts were rearranged and continuous blowing was carried out for 30 hours on one cupola.

The cupola lining was in two sections—an outer ring of 9 in. Stourbridge firebricks with an inner lining, 1 ft. 1½ in. thick, of 42 per cent. alumina blocks from the base to the charging sill. Stourbridge firebrick blocks were used for the remainder of the shaft. After a single run the lining had burned back 10 in. all round, from tuyere level upwards for 2 ft. This continued upwards for a further 3 ft. with a gradual taper to 5 in. depth. Fettling was carried out with used firebricks and ganister, an average of 38 cwt. and 60 cwt., respectively, being used for each repair. This gave a total refractories consumption of 73 lb. per ton of metal melted. On double-shift running the lining was fettled up to a diameter of 6 ft. 6 in., and on single-shift working to 7 ft 6 in. diameter for 4 ft. above the tuyeres, the consumption of refractories per ton of metal being of the same order for both single- and double-shift working.

The remelted metal was very consistent in composition, and contained 3·2 per cent. total carbon, 0·3 per cent. silicon, 0·5 per cent. manganese, with sulphur and phosphorus according to the quality of coke and steel scrap. Welsh foundry coke containing 0·6 per cent. sulphur was used, and normally resulted in a sulphur content in the metal of 0·15 per cent. This coke was also particularly suitable physically for the charging and melting conditions of the cupolas, and its use was standardised early in the operation of the foundry. It was found necessary to increase the coke charge if, owing to emergencies, other brands had to be used. As these invariably had a higher sulphur content, this was reflected in the remelted metal, and on occasions, especially when accompanied by the use of consignments of poor quality scrap, the sulphur in the remelted metal rose as high as 0·30 per cent. It was always possible to deal with this by a desulphurising technique described later in the paper. The phosphorus varied from 0·04 to 0·08 per cent., according to the steel scrap being used, but for long periods the variations were 0·04 to 0·05 per cent. Two interesting features were that the phosphorus content in the first ladle was generally 0·01 per cent. higher than in subsequent ladles, and that a small reduction in phosphorus occurred during desulphurisation.

The remelted metal was desulphurised with sodium carbonate before further use, and in the early stages, when hematite pig and selected steel scrap constituted the cupola charge, sulphur reduction to 0·05 per cent. was easily carried out by the usual process, using 25 lb. of sodium carbonate per ton of metal. With the introduction of the rotary furnace and the use of 100 per cent. steel scrap, it became increasingly difficult to obtain low-sulphur metal, and investigation had to be made into the desulphurising technique. Some improvement was obtained from the use of the "granular" as distinct from the "dense" quality of sodium carbonate, but this was not of the order required and experiments were carried out in which the method of the addition was varied.

The method finally adopted was to use two treatment ladles. Owing to the high sulphur content of the metal, it was necessary to use 30 lb. of sodium carbonate per ton. This was fed into the first ladle (a 5-ton tilting receiver) as it was filled, the necessary amount for the treatment of 5 tons being added by the time that the ladle was half-full. The whole of the contents of this ladle were then poured into the second one resulting in a further reaction between metal and slag. The slag was then removed and the metal passed on to the next stage of the process. By this means, a sulphur reduction of 75 per cent. was obtained, which relieved all anxiety on this account. Carbon, silicon and manganese were also reduced and there was a temperature decrease of 75 deg. C., but as the tapping temperature was of the order of 1,475 deg. C., this was not serious.

Several lining materials were tried and the final practice adopted was a basic lining for the first ladle and an acid monolithic material for the second. When the receivers were lined with Stourbridge firebricks (34 per cent. Al_2O_3) jointed with similar fireclay, the soda attack necessitated patching after 20 heats (100 tons), and the top three courses had to be replaced after 50 heats (250 tons). When 42 per cent. Al_2O_3 bricks were used, this life increased to 360 heats (1,800 tons) with patching of the joints at the end of each shift.

It was found that neither of these linings was satisfactory for the continuous run of a double-shift working and the use of a basic lining was therefore adopted which stood up satisfactorily to these conditions. The bottom was first covered with a layer, 1 in. thick, of a mixture composed of three parts Doloset and one part Dolopatch, on which was placed two courses of Dolofer squares jointed with Dolofer cement. The walls were built with Dolofer side arches, behind which was rammed 1 in. of the above mixture. The top was daubed with Doloset and the whole of the inside was finished with a wash of Dolofer cement. Drying was carried out by means of a small gas flame adjusted so as not to touch the brickwork. The flame was left in for three days and the receiver was then half-filled with a coal fire and allowed to burn out.

At the end of the double-shift run, a repaired receiver was put into use. The used one was allowed to cool, the wall surfaces cleaned of skull, etc., and daubed with the 3 : 1 Doloset-Dolopatch mixture. Spalling took place near the top, and towards the end of its life it was repaired by the insertion of two courses of Dolofer splits to avoid the necessity for complete relining. This repair was more durable than the normal daubing. The receivers dealt with 1,900

* Paper entitled "Mass-Production Methods Applied to the Manufacture of Cast-Steel Bomb Bodies," presented at the 44th Annual Conference of the Institute of British Foundrymen, at Nottingham, on Wednesday, June 18, 1947.

tons to 2,000 tons of metal before requiring complete relining. The transfer ladles were of 8 tons capacity, and experiments were made with brick and monolithic linings. The former was of 34 per cent. Al_2O_3 Stourbridge "circles on edge," 2½ in. thick, which were daubed with a proprietary brand of plastic refractory at the end of each shift. The life between relinings was 300 heats (1,500 tons)

Soda attack occurred chiefly at the brickwork joints, and monolithic linings were found necessary in order to obtain freedom from trouble during the periods of operation resulting from the double-shift working of the plant. These were rammed with an acid material with a wall thickness of 2 in. and the bottom 1½ in. thick, finished with a course of firebrick. For drying, a coke fire was made inside and allowed to burn out, the ladle being finally brought to red heat before use by placing upside down over a gas burner. Repair consisted of cleaning off skull, etc., and facing up with plastic refractory material. The life before relining was necessary depended on the amount of skulling, and varied between 1,800 tons and 2,000 tons throughput of metal.

There were two rotary furnaces of the Sesci type, of 12 tons nominal capacity, fired by pulverised anthracite produced in a plant attached to this section. One of these is shown in Fig. 3. The waste gases were utilised in recuperators to preheat the incoming air, the pulverised fuel being fed positively into the air main at a suitable point near the furnaces. Each furnace was connected to two storage hoppers holding pulverised bituminous and anthracite coal, respectively, and the maximum feed was 20 cwt. per hour. The air supply was from Holmes-Connersville positive blowers with maximum outputs of 3,250 cub. ft. per minute at 24 in. water gauge. The lining material, the fusion point of which was over 1,700 deg. C., was of the composition and grading shown in Table I.

TABLE I.

Constituent.	Per cent.	Grading.	Per cent.
Silica	87·8	Left on 8 B.S.I. sieve ..	22
Alumina ..	3·8	,, 16 ,, ,, ..	10
Iron oxide ..	3·0	,, 30 ,, ,, ..	7
Lime	1·6	,, 60 ,, ,, ..	10
Magnesia ..	0·6	,, 150 ,, ,, ..	20
Alkalies ..	0·2	,, 300 ,, ,, ..	11
Loss on ignition.. ..	2·9	Less than 300 B.S.I. sieve	20

The shell of the furnace was placed vertically in a suitable pit and the lining rammed in with pneumatic rammers round a sectional metal former. The water content of the material was carefully controlled at from 6 per cent. to 8 per cent. The ramming operation was continuous and took 80 hours to 100 hours, 40 tons of material being used. After the formers were removed, a preliminary skin drying was carried out by means of a coke-fired mould dryer. This was placed on the top of the furnace, which was still in the vertical position, and a long steel tube was connected to the outlet, reaching to the opposite end of the furnace.

After 24 hours, the furnace was removed from the pit and placed horizontally on the rollers in its working position. A self-contained unit, comprising a horizontal gas burner with an integral blower, was then placed in position at the exit end, and heating by gas commenced. A protected thermocouple was inserted through the charging spout to within ½ in. of the inside face of the lining, and the gas burner was adjusted to raise the temperature to 200 deg. C. in 24 hours. It was increased to 300 deg. C. in a further 24 hours, and finally to 600 deg. C. in a further 24 hours. After this, the pulverised-fuel feed was commenced, to raise the temperature to fritting point in 6 hours. The lining was then kept at 600 deg. to 900 deg. C. by gas jet or pulverised-fuel feed until required for use. The lining wear was not excessive, but at the end of each day a frit was applied which consisted of 8 cwt. of silica sand.

By careful control of raw materials, ramming, drying, operation and repair, the average life of a lining before knocking out was of the order of 10,000 tons, the best life recorded during the last eight months of operation, being no less than 16,500 tons. In the latter case, the consumption of refractories per ton of metal was 60 lb. of lining material and 6 lb. of patching.

The furnace was started up on bituminous pulverised fuel, and gradually changed over to anthracite as the temperature rose. This position was reached in 30 minutes, and the first metal was charged 1 hour after starting up. All controls were centralised at an instrument panel. Indicators showed the temperature of the waste gas and incoming air, and the fuel and air feeds were shown on dials. There were two tapping holes on the furnace, diametrically opposite, situated in the centre of the horizontal line of the barrel. They served for both filling and teeming, and, with normal semi-rotational working, only one was open. In order to equalise wear, the tapping holes were periodically changed over, either during the mid-day break or at the end of the shift.

MANUFACTURE OF CAST-STEEL BOMB BODIES.

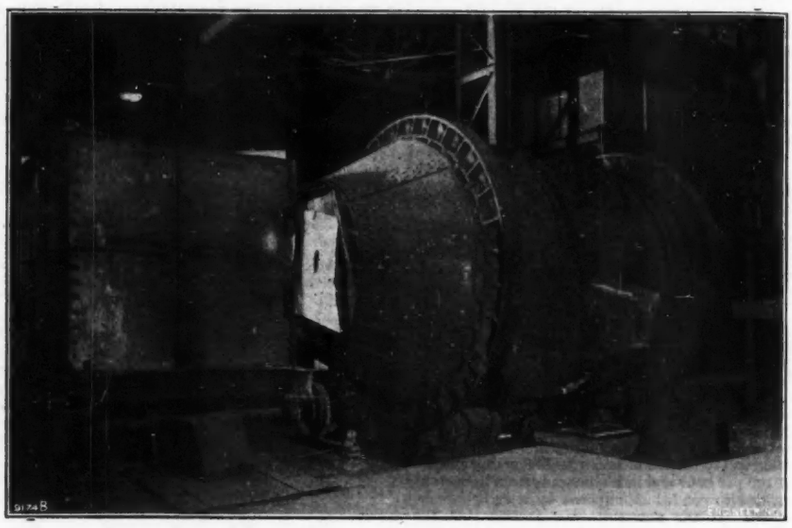


FIG. 3. ROTARY FURNACE.

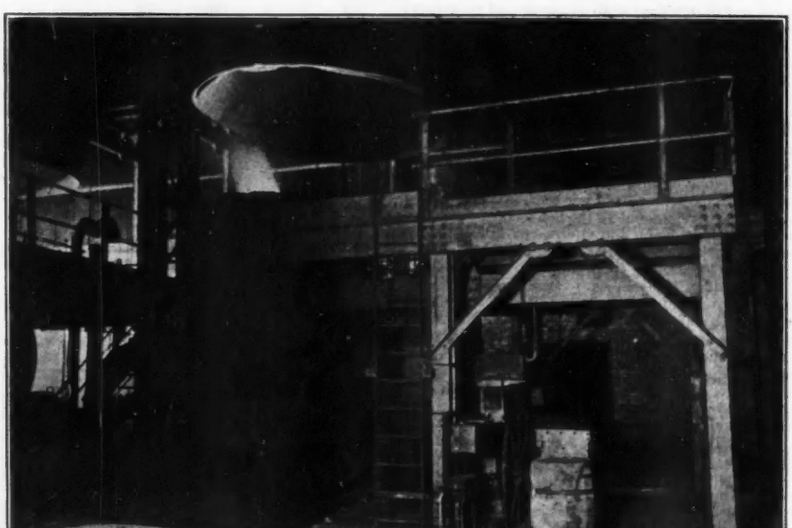


FIG. 4. TROPENAS CONVERTER.

The calorific input was adjusted to raise the iron to the required temperature (1,500 deg. C. minimum) at the rate of 15 tons per hour. The fuel feed for these conditions was 11 cwt. per hour, or approximately 80 lb. per ton of iron. The corresponding air feed was 2,700 cub. ft. per minute. The waste-gas temperature was 700 deg. C., and that of the incoming air, 400 deg. C. Operational difficulties were experienced if the air temperature rose much above 400 deg. C., and there was an arrangement to by-pass some of the waste gas directly to the chimney, in order to control this temperature. The above ratio of fuel to air resulted in the most efficient working and non-oxidising conditions, and a check was periodically made by diverting the fuel feed into a weighed receptacle over a timed period.

To maintain the rate of production in the foundry, it was only necessary to operate one of the rotary furnaces at any one time, and the general method of operation was first to superheat 10 tons to the required temperature. A suitable amount (55 to 70 cwt.) was then tapped out for the first converter heat and a further 5 tons poured in. From four to six batches per hour of 55 to 70 cwt. were tapped out and continually replaced in lots of 4 to 5 tons. The ladle for the superheated metal was of 4½ tons capacity, lined with firebrick. There was very little change in the composition of the rotary-furnace metal between charging and tapping, the chief difference being slightly lower manganese and sulphur. The temperature increment was of the order of 150 to 200 deg. C.

The anthracite fuel was prepared in a separate plant from Welsh washed duff. It consisted of a storage bunker below ground level, a vertical bucket conveyor to an overhead bunker, and a coal-fired hot-air dryer with a fan to draw off water vapour. A second elevator delivered the dried anthracite to a 48-in. ball mill. The screening was to a nominal 100 mesh, all rejects being returned to the mill. From the mill, the fuel was fed to storage hoppers by a Fuller-Kinyon feed pump. The analysis and final grading were as given in Table II, on the opposite page. The calorific value of the fuel was 14,100 B.Th.U. per lb.

There were four side-blown converters, each of 3 to 3½ tons capacity, one of which is shown in Fig. 4. In the original design they had silica brick linings throughout, but this was altered, very early in the operation of the plant, to silica brick body and monolithic lined nose. Each converter was fitted with

six 1¼-in. diameter tuyeres, and the internal shape of the body was oval. When a vessel was re-tuyered, five, of 2 in. diameter, were put in to reduce to a minimum interference with the remainder of the lining. The construction of the body lining comprised a 1-in. layer of asbestos wool between the shell and a first layer of bricks, followed by a lining of silica-brick arches 4½ in. thick and an inner lining of silica blocks. These were 15 in. thick on the tuyere side, graduating to

TABLE II.

Analysis.	Per cent.	Grading.	Per cent.
Moisture ..	1·5	Left on 100 B.S.I. sieve..	2
Ash	6·0	,, 200 ,, ,, ..	12
Volatile ..	11·5	Through 200 B.S.I. sieve	86
Sulphur ..	0·7		
Carbon ..	80·3		

10 in. thick on the teeming side. The bottom was made up with firebrick squares laid flat and two courses of silica brick squares. The first course was laid flat and the inner course laid on end. All joints were made with a finely-ground siliceous cement and as thin as possible.

The nose was rammed separately with pneumatic rammers round a collapsible metal former, with material of properties similar to those of the refractory used in the rotary-furnace lining. After the removal of the former, the lining was allowed to air-dry, and was then skin-dried by a fire-bucket placed inside. It was next fitted to the body, which was removed from the lining pit and drying commenced. A small gas pipe was inserted through the centre tuyere and the flame adjusted to raise the temperature slowly from 300 to 600 deg. C., this stage being reached in a minimum of 48 hours. The vessel was then moved to the blowing position and a fire started with wood and coal, after which coke was charged. It was allowed to burn with natural draft through the tuyeres for 10 to 12 hours, the tuyere cover was placed in position, and a very slow blast applied for one hour. The remaining coke was emptied from the vessel and the first heat was charged. For information on the temperature conditions of the lining during drying and blowing, thermocouples were inserted in a hole drilled in the inner 10 in. block to within 1 in. of the working face. The temperature recorded showed the following: 0 to 300 deg. C. in 20 hours with gas heating; 300 to 600 deg. C. in a further 22 hours with increased flame; 600 to 1,000 deg. C. in a further 4 hours with coke burning; 950 to 1,000 deg. C. maintained for 6 hours; and 1,300 deg. C. reached in 1 hour with blast through coke fire. The temperature dropped approximately 75 deg. C. during the period of charging the iron prior to blowing, and rose to 1,450 deg. C. at the end of the blow. Other thermocouples at equidistant points from front to back of the 10 in. inner lining recorded proportional rises in temperature, a maximum of 400 deg. C. being shown at the end of the blow, 10 in. away from the working face.

In the operation of the converters, 80 lb. of silica sand were first charged into the vessel, the object being to provide an acid oxide to combine with the large amount of iron oxide produced early in the blow. Its effect on lining life will be referred to later. Iron from the rotary furnace was then poured in from a ladle suspended on a crane balance. The amount varied with the amount of lining wear, a new vessel taking 55 cwt., which increased to 75 cwt. at the end of its life. The practice of "setting the tuyeres" was carried out, the vessel being tilted back to the blowing position until the metal reached the bottom of the tuyeres. This resulted in a blowing angle of 5 to 10 deg. from the vertical. The tuyere box cover was then put in place, and blowing commenced at a volume of 3,500 to 4,000 cub. ft. per minute with 3½ to 4 lb. per square inch pressure. Each converter had a separate Holmes-Connersville positive blower with a maximum output of 5,000 cub. ft. per minute at 6½ lb. per square inch. Slight adjustments to volume and angle were made during the blow, but an effort was made to maintain as nearly as possible the original setting throughout. Small additions of 75 per cent. ferro-silicon were made at the beginning of the blow if the temperature of the rotary-furnace metal was below normal.

The duration of the blow was from 8 to 12 minutes. The vessel was then tilted forwards and the slag raked off the blown metal. Deoxidation was carried out by 4½ lb. per ton of stick aluminium, tied to a long rod which was plunged into the bath. The necessary alloying elements were then added, the metal poured into the casting ladle, and transferred by an electric jib crane to the foundry casting platform. The alloys added to a 65-cwt. heat were 110 lb. of ferro-manganese, 12 lb. of ferro-silicon, and 37 lb. silico-manganese. The percentage composition of the finished steel was as follows:—Carbon, 0·22 to 0·25; silicon, 0·30 to 0·40; manganese, 1·4 to 1·6; sulphur, 0·05 max.; and phosphorus, 0·04 to 0·07. After heat treatment, the physical tests on a 0·564 in. diameter bar were well above the A.I.D. specification of 35 tons per square inch minimum tensile strength and 20 per cent. minimum elongation.

In the first weeks of operation, there was some concern with regard to the very short converter life, which averaged 30 heats per lining. Improvements in methods of lining, drying and repair increased this to 90 heats per lining. When the rotary furnaces were brought into use, the converter life dropped again, and it was realised that it was due to iron oxide attacking the lining in the absence of oxidised silicon from the metal charge.

To provide an acid oxide to combine with the large quantities of iron oxide produced in the early stages of the blow, silica sand was introduced into the vessel before the liquid iron. Experiments were carried out to determine the optimum amount of sand for this addition. It was found, from chemical analysis of the slag and its viscosity, that 80 lb. of sand resulted in ideal conditions and an immediate improvement in lining life to 140 heats took place. This was subsequently increased to 250 heats per lining, but final practice was to take the vessel out of service after 200 heats, strip down the inner lining where necessary and brick up to original shape. The record life of an inner lining was 356 heats. A life of 1,500 heats was obtained before complete relining was carried out, but the vessels were re-tuyered after 100 heats.

Patching was carried out as soon as the last metal was poured from the converter. A proprietary siliceous plastic refractory was mixed to a creamy consistency and poured from a long-handled bucket on the worn parts of the teeming side. The tuyere side was similarly treated, bars being placed inside the tuyeres to act as formers. After 25 to 30 heats, the nose was patched with slightly thicker material smoothed over with a flat steel spade on a long metal rod.

(To be continued.)

NOTES ON NEW BOOKS.

Ships and Shipyards of Bideford, Devon, 1568 to 1938. By INKERMAN ROGERS, F.G.S., F.R.A.S. Bideford Borough Council, Municipal Buildings, Bideford. [Price 5*s.* net.]

SHIPBUILDING in wood, as an industry of the British Isles, has never received from historians the attention that it deserves; but whoever attempts the task, which must increase in difficulty with each year that passes, will owe a great debt to such industrious researchers as Mr. Inkerman Rogers for having exhumed and recorded much information that is not only worthy of record, but may serve to direct further inquiries. Bideford, in its day, was a shipbuilding centre of considerable importance; the biggest wooden ship listed by Mr. Rogers was of 1,220 tons, a size that would have been regarded anywhere as noteworthy at the date of her launching, 1855. The author's personal acquaintance with local shipbuilding covers more than 70 years and his painstaking industry has done much to offset the "extraordinary series of mischances" which, his preface states, "has destroyed most of the original documents and records which should have remained in the possession of the town." The ship lists that he gives (separately for Bideford and Appledore) are long, and a biographical note reveals that he is now in his 82nd year; so it is in no carping spirit that we point out that he has not yet exhausted the possibilities of *Lloyd's Register*. The volume for 1856, we happen to know, names over 80 Bideford-built vessels then afloat which do not appear in his lists; and at that time the *Register* included only vessels "classed" by the Society. It is evident, therefore, that the shipbuilding industry of the district was even greater than this book indicates, and that there is scope still for further research. Meanwhile, Mr. Rogers has laid a firm foundation, on which others may build but which they are not likely to disturb.

The Maryport and Carlisle Railway. By PROFESSOR JACK SIMMONS. The Oakwood Press, 30, White Horse Hill, Chislehurst, Kent. [Price 4*s.*, paper covers; 5*s.*, bound in cloth.]

IT is refreshing to read an essay on a pre-amalgamation railway that has been written by an author with literary and historical qualifications. Professor Simmons has cast his net wide in the search for documentary evidence, and he obviously became well imbued with the character of the Maryport and Carlisle Railway before he attempted to write this history. It is No. 4 of the Oakwood Library of Railway History, and, in common with the other three that have been published, it is quite short; but this has not prevented the author from giving a balanced and informative account. The foundation and growth of the railway are seen in relation to the commercial development of that part of North-West England, especially the West Cumberland coalfield; and the author has written briefly on the company's officers, the train services, stations, locomotives and other rolling stock. Financially, the Maryport and Carlisle Railway was eminently successful, except for an initial period of trouble due to mismanagement; and it successfully resisted absorption, from the opening of the first section in 1840, until the amalgamations in 1922. George Stephenson made a preliminary survey for the line in 1836, and he remained the company's engineer until November, 1839, when he resigned and was succeeded by John Blackmore. In the same month, the Maryport and Carlisle Railway was one of three proposed routes from London to Scotland, the relative merits of which were considered by commissioners appointed on a motion of the House of Commons. It was not chosen for this purpose, however, owing to its greater length, and the fact that the scheme involved the crossing of Morecambe Bay. Thus it remained, as Professor Simmons notes, "a perfect specimen of the small, independent local railway company." The book is illustrated with sketch maps of the line, and reproductions of several interesting old photographs.

British Coaster, 1939-1945. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

THIS official story of the work of British coasting vessels during the recent war has been prepared for the Ministry of Transport by the Central Office of Information, while evidently designed with due regard to inland readers who may be unfamiliar with the types and functions of coastal shipping, should be of interest also to those who possess more expert knowledge. In general, it follows the style of the other popular brochures dealing with various aspects of the national war effort, and, like them, is of value for the insight it gives into the war-time operation of a branch of transport of which the public do not always appreciate the importance.

An Anthology of Clocks and Watches. By DR. C. A. O. FOX. Published by the compiler at Valley House, Bishopston, Swansea. [Price 8*s.* 6*d.*]

THE making of clocks and watches, though not commonly regarded as a branch of engineering, touches at so many points the various sciences—mechanics, metallurgy, metrology, etc.—on which engineering depends, that it deserves to be considered as such; but its purpose, the measurement of time, induces also a philosophic mood which has recurred again and again in the published reflections of thinkers and writers. In this distinctly unusual booklet, Dr. Fox has collected a remarkable variety of such references, dating from Dante to the present day, adding to them a number of explanatory notes—very necessary, in some cases—and some admirable illustrations of outstanding examples of the clockmaker's art and craft. To this collection, perhaps we may add one more, of a definitely engineering interest: namely, the clock which, for 70 years or more, timed the labours of the employees in the Lambeth works of Maudslay, Sons and Field and continued, for another 40 years, to do the same for those of the Maudslay Motor Company. An illustration of it, on page 347 of our 157th volume (1944) shows clearly the inscription, "Remember! Time wasted cannot be regained," reputed to have been painted on the dial on the instructions of Henry Maudslay himself.

Production Costs and Estimates. Enlarged edition. *Practical Cost Accounts.* Fourth edition. By ANDREW MILLER, J.P. Gee and Company (Publishers), Limited, 27-28, Basinghall-street, London, E.C.2. [Price 12*s.* 6*d.* net each.]

THE first-mentioned of these two books was published originally in 1924, under the title *Technical Costs and Estimates*; the other appeared first in 1931, and was amplified subsequently by the addition of chapters on "Standard Costs" and "Budgetary Control." Together, they form a useful guide to the theory and practice of their respective subjects, as applicable to the requirements of an engineering works of moderate size, and show ample evidence of the author's long and responsible experience on the financial side of Clydeside engineering. They should be of value, not only to those who are in process of acquiring similar experience, but also to candidates preparing for examinations in engineering economics and administration. We would suggest, however, that it might be worth while if the author were to consider combining them into a single volume; even though this would involve a certain amount of rewriting, it would probably be a convenience to many readers in both of the categories indicated.

CATALOGUES.

Milling Cutters, Drills and Tools.—Messrs. Machine Accessories, Limited, 8, Lodge-road, St. John's Wood, London, N.W.8, have sent us their stock list of milling cutters, drills, drill and lathe chucks, machine vices, caliper gauges and other tools.

Hoisting Trucks.—Brief particulars of their petrol-driven pneumatic-tyred lifting, hoisting and stacking trucks, mobile cranes, and other vehicles, are contained in a leaflet issued by the Hyster Company, 2902, N.E. Clackamas-street, Portland, Oregon, U.S.A.

Drill-Chuck Guard.—Messrs. Air Ducts, Limited, Great West-road, Brentford, Middlesex, have issued a leaflet describing their Decon drill-chuck guard, consisting of two semi-cylindrical transparent sections, moulded on a 3-in. radius and fitted in a strong metal frame.

Crucible Furnaces.—A catalogue describing and illustrating their lip-pouring hydraulically-tilted oil or gas-fired crucible furnaces has been issued by the Morgan Crucible Company, Limited, Battersea Church-road, London, S.W.11. Five sizes are available, the capacities of which are, respectively, 400 lb., 600 lb., ½ ton and ¾ ton of brass, and ¼ ton of aluminium.

Motor-Vehicle Data Sheets.—The Associated Equipment Company, Limited, Southall, Middlesex, have issued two new data sheets, which cover their complete range of passenger and goods vehicles, respectively. The data sheets are exceptionally comprehensive and provide all leading dimensions, weights, axle ratios, etc., as well as brief details of the engines and ancillary equipments.

Hydraulic Transmissions.—We have received from Messrs. Hydraulic Coupling and Engineering Company Limited, Worton-road, Isleworth, Middlesex, a brochure describing some of the many methods of using hydraulic couplings in conjunction with electric motors. The examples given cover a wide range of applications, including the driving of conveyors, coal-crushing plant, yarn-spinning machinery and centrifugal pumps.

Precision Grinding Machine.—The Merlin grinding machine for valves and small precision parts is described in a leaflet prepared by the manufacturers, the Merlin Engineering Company, Limited, Hebble Mills, Salterhebble, Halifax, and issued by Messrs. E. H. Jones (Machine Tools), Limited, Edgware-road, The Hyde, London, N.W.9, who are sole export distributors. The machine is supplied with a floor stand or for bench mounting; it is only 33 in. long and 21 in. wide.

Creep-Resisting Steels.—An illustrated catalogue on the creep-resisting steels produced by Messrs. Samuel Fox and Company, Limited, Stocksbridge Works, Sheffield, has been sent to us by the United Steel Companies, Limited, 17, Westbourne-road, Sheffield, 10. It deals with a series of steels developed during the past 12 years for specific uses under high-temperature conditions. Interesting scientific data on creep testing and the manner in which long-time creep tests are conducted are included.

Superheaters.—The Superheater Company, Limited, 53, Haymarket, London, S.W.1, have sent us two booklets on locomotive superheaters and one on marine superheaters. The first booklet deals at some length with the design and construction of the MeLeSco superheater, header, multiple-valve regulator, automatic drifting valve, and sand gun; and the second is the fourth edition of a booklet which describes the installation, maintenance and operation of locomotive superheaters. The third booklet contains a description of superheaters for several types of marine boilers.

Friction Clutches.—Messrs. Borg and Beck Company Limited, Tachbrook-road, Leamington Spa, have issued a brochure dealing with their standard range of transmission clutches. Full technical details of each type of clutch are given, the sizes ranging from a 6½-in. clutch capable of transmitting a torque of 38 lb. ft. to a 16-in. clutch capable of transmitting a torque of 600 lb. ft. The brochure calls attention to the fact that this firm also manufacture specialised clutches for industrial applications and states that a heavy-duty flexible centre will be available shortly for the 12 in., 14 in. and 16 in. sizes of standard clutch.

Water-Tube Boilers.—Messrs. Yarrow and Company, Limited, Scotstoun, Glasgow, W.4, have issued a well illustrated booklet dealing with the water-tube boilers installed by them at Castle Meads power station, Gloucester. This station was erected during the war, two 100,000-lb. boilers and a 20,000-kW turbo-alternator being commissioned in December, 1942, two years and four months after the contracts had been placed. Three further boilers, and a second 20,000-kW set have since been added. Full technical particulars of the boilers and associated plant are given in the booklet, together with details of the official tests on one of the boilers, which show that during six hours steaming at a normal load of 75,000 lb. per hour, a net overall thermal efficiency of 85·88 per cent. was obtained, compared with the guaranteed figure of 82·04 per cent.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

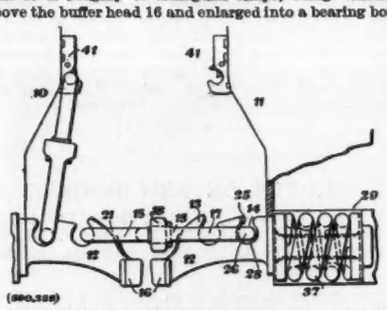
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MINING.

590,238. Coupling for Mine Cars. English Steel Corporation, Limited, of Sheffield, and G. D. Whitehouse, of Sheffield. (8 *Figs.*) March 29, 1945.—This invention is a coupling for mine cars and railway wagons which enables each car or wagon of a train to be rotated about a horizontal axis to empty its contents without uncoupling it. Two mine cars 10, 11 are each fitted with a hook body 12 consisting of a coupling hook proper 13, an anchoring slot 14 for a link 15 carried by the car and a buffer head 16 extending in front of and below the hook 13 in the form of a curved bar extending laterally on each side of the hook body 12. The anchoring portion 17 of the link 15 is roughly of triangular shape, being widened above the buffer head 16 and enlarged into a bearing boss



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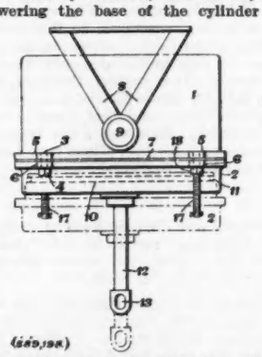
18 which enables the portion 21 of the link to swivel in the portion 17. The end of the anchoring portion 17 remote from the boss 18 is hooked in the slot 14 which has an entrance 25 slightly narrower than the larger dimension of the flattened or oval section 26 of the portion 17. The risk of accidental detachment of the portion 17 is thus reduced. The main portion 28 of the slot 14 is wide enough to allow the portion 17 to swing freely. The hook body 12 of the car 11 is connected to a combined drawing and buffing gear indicated generally at 29, the coiled spring 37 of which takes the drawing and buffing stresses. The idle coupling link of one of the cars is held clear of the hook body by a catch 41 secured to the car body vertically above the anchoring slot 14. (*Accepted July* 11, 1947.)

RAILWAYS AND TRAMWAYS.

589,198. Vacuum Brake. The Consolidated Brake and Engineering Company, Limited, of Slough, and B. W. Palmer, of Slough. (6 *Figs.*) March 19, 1945.—This invention relates to the cylinders of vacuum-brake apparatus for railway vehicles, and its object is to facilitate lowering the base of the cylinder for the



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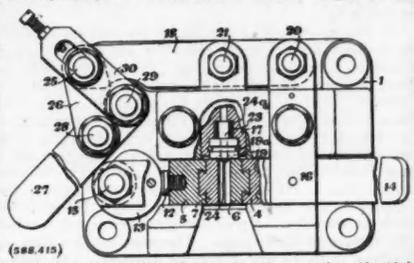
purpose of inspecting and renewing the rolling and jointing rings while the main body of the cylinder remains suspended by its trunnions, and subsequently raising the base into position for rejointing it to the cylinder body. The brake cylinder consists of an upper portion 1 and a base portion 2 secured together by studs 3 and nuts 4, the studs being mounted in lugs 5 on the body portion 1 and extending through holes in complementary lugs 6 on the base portion 2. A packing ring 7 is interposed between the portions 1 and 2. Hangers or brackets 8 suspend the cylinder from the vehicle underframe, the cylinder body having trunnions 9 journalled in bearings in the hangers 8. The brake piston 10 (shown in dot and dash lines) is equipped with a rolling ring 11 and piston rod 12, the latter having a crosshead 13 for engagement with the brake lever. The body 1 of the cylinder is provided at each of two diametrically opposite points with a relatively long vertical stud 17, which may be termed a jack stud, mounted in the respective lug 5 and extending through the hole in the complementary lug 6 projecting laterally from the base 2, these jack studs 17 being equipped with nuts 18. If desired more than two jack studs may be provided, spaced equidistantly round the base. The jack studs are threaded throughout the length of their shanks. To lower the base unit 2 from the body portion 1 of the cylinder, the nuts 4 are removed from the securing studs 3, and the nuts 18 on the jack studs 17 are slackened, permitting the base to drop until it is spaced the desired distance from the body to permit the rings 7 and 11 to be inspected and, if necessary, changed. During this time, the base remains suspended by the jack studs and nuts. To raise the base for re-jointing to the body, the nuts 18 on the jack studs 17 are screwed up until the base is in its normal position against the body portion of the cylinder. The nuts 4 are then replaced and screwed up on the securing studs to effect the re-jointing of the base to the cylinder body, the nuts on the jack studs also being screwed home. (*Accepted June* 13, 1947.)

MISCELLANEOUS.

588,415. Machine for End-Forming Metal Tubes. R. B. Pullen and Company, Limited, of Brentford, Middlesex, and H. H. Hebden, of Willesden, London. (5 *Figs.*) February 16, 1945.—This invention is a machine for the production of nipples at the ends of metal tubes for the purpose of forming couplings. One of the objects of the invention is to provide a tube with a nipple having a flat shoulder adjoining an incurved nozzle-like end, while a further object is to avoid the need of any backing washer of special section which is necessary in some known types of coupling. The base 1 of the machine has a slide way which receives a fixed vice block 4 and a sliding vice block 5. These blocks carry removable jaws 6, 7 to fit the outside diameter of the tubing, gripping surfaces being roughened. A guide pin is secured in the fixed vice block 4 and passes through a hole in the lower part of the sliding block 5. A coiled compression spring encircles the pin and consequently separates the blocks and the jaws 6, 7 when the pressure on the block 5 is relieved. A pressure button 12 is secured in the outer face of the block 5 and is engaged by the face of a cam 13 provided for closing the jaws 6, 7. The cam 13 and a hand-lever 14 are coupled together and turn on a cam-stud 15 screwed into the base 1. The lever 14, when in the active position, passes over the top of the jaws 6, 7 into a position below a transverse bar 16 fixed to the base 1 thus boxing in the jaws 6, 7. Underneath the bar 16 is a pivot block



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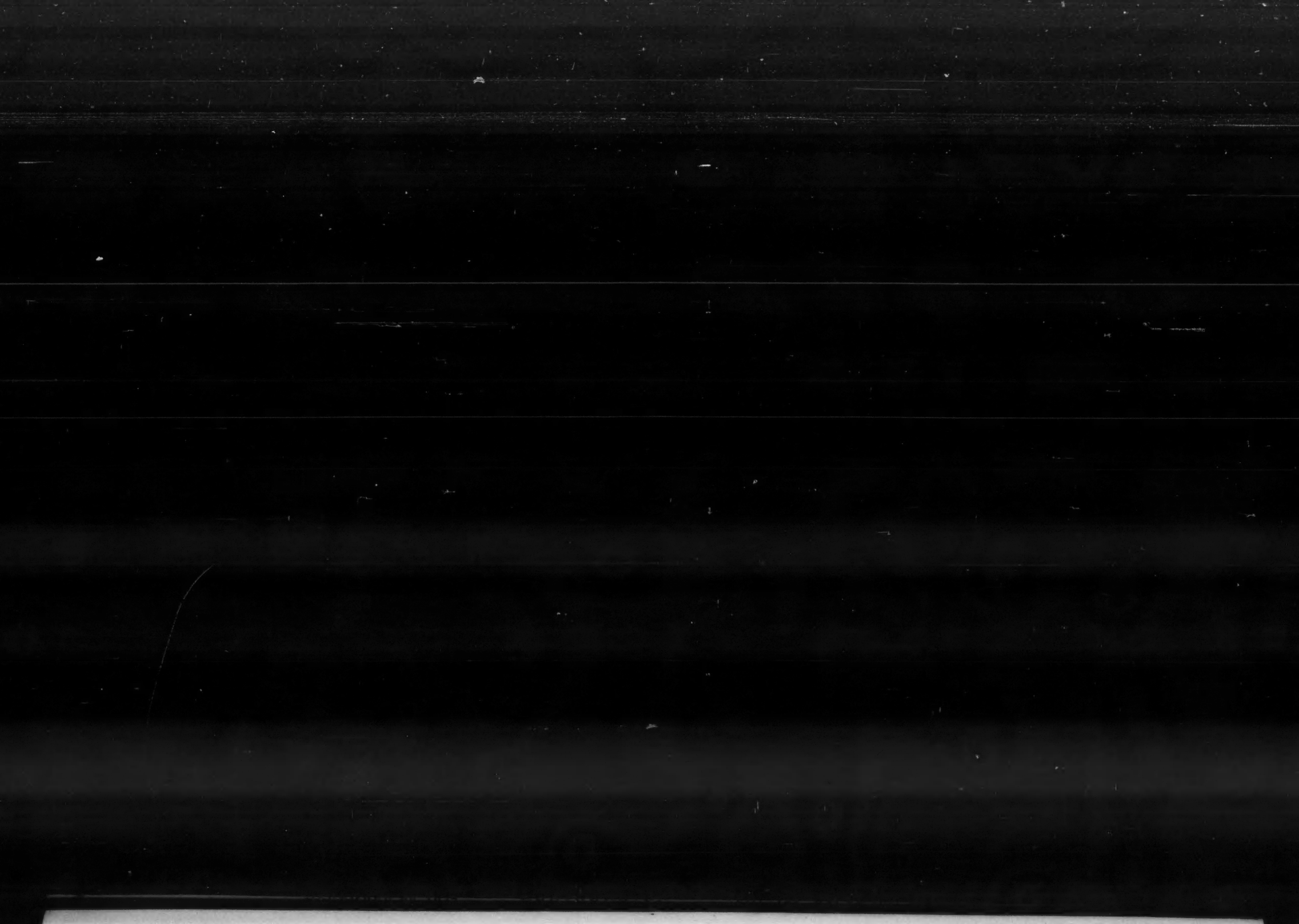
in which a lever 18 that operates the swaging die 19 is pivoted. The lever 18 turns about a pivot stud 20 and is pivoted by a stud 21 to a die block 17 through which it passes, so that if the lever 18 is turned down as shown, the die 19 is moved towards the vice jaws 6, 7. The die block 17 slides in a slideway in the base 1 at right angles to the groove of the vice blocks 4, 5, and to enable the block 17 to slide freely, the pivot stud 21 passes through the slot in the lever 18. The forming die 19 is of hardened steel and is secured in the block 17 by dowel screws 19a. It bears against a shoulder 23 on a pin 24, so as to retain the latter in position. The pin 24 is a sizing pin for maintaining the inner bore of the tubing, the end of which it enters during the forming operation. A coiled compression spring 24a surrounds the enlarged back end of the pin 24 so as to eject the die 19 when the screws 19a are removed. A pin 25 is carried by the end of the lever 18 and serves as a pivot for connecting a link 26, which is secured to the operating lever 27 by a stud 28. The lever 27 turns about a pivot stud 29 secured in the base 1. To perform the swaging operation, the lever 27 is turned counter-clockwise pulling in the lever 18 and forcing the die 19 towards the face of the vice blocks 6, 7. A limiting link 30 is provided to ensure that the correct length of the tubing shall overhang the vice jaws 6, 7 to form the nipple. (*Accepted May* 21, 1947.)